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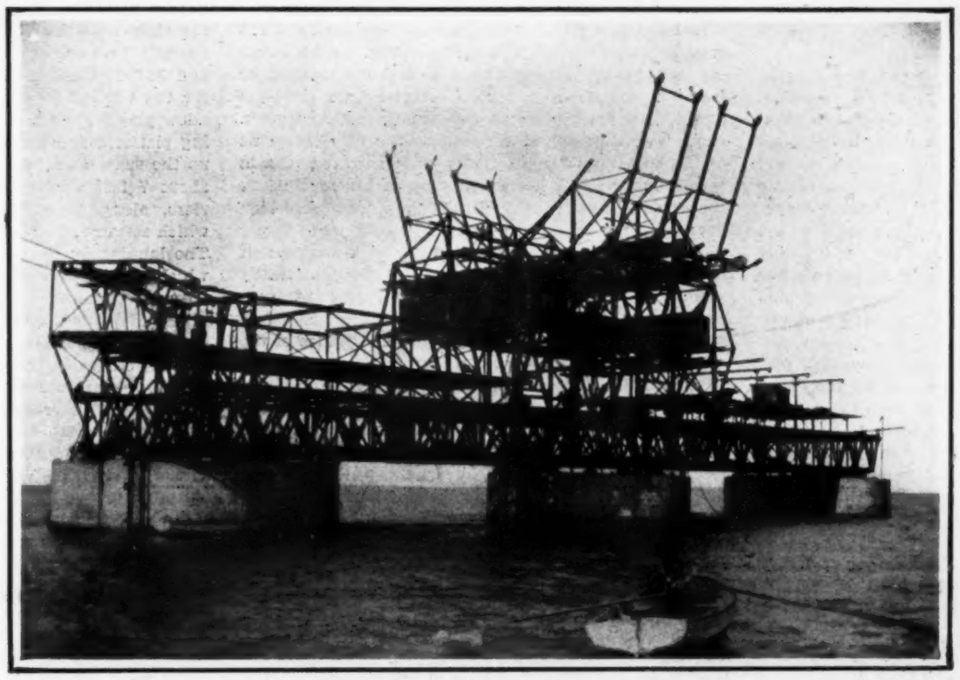
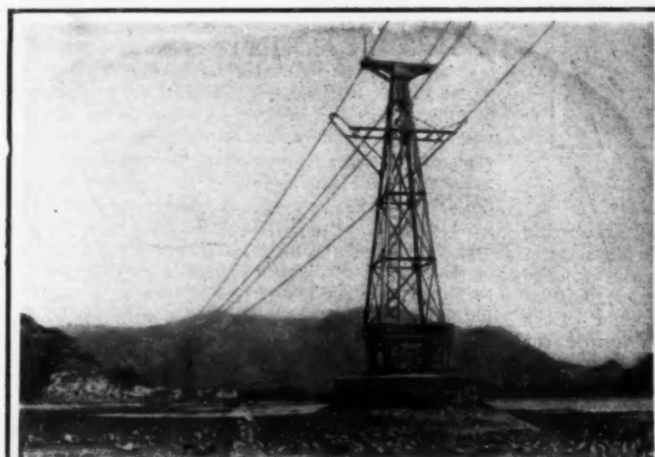
AN INTERESTING AERIAL CABLEWAY AND ORE-HANDLING PLANT IN NEW CALEDONIA.

By Our English Correspondent.

Although the French convict settlement of New Caledonia in the Southern Pacific has a prosperous mining industry, its development has been retarded by the absence of adequate facilities for the transportation of the ore to vessels, the existence of a coral reef-bound coast and heavy surf rendering the approach of vessels to the mainland highly dangerous. The loading and unloading of ships proved difficult, tedious, and expensive, while vessels of heavy tonnage could not be dealt with. To erect a landing stage projecting from the coast line to clear the reefs would have been too costly and too slow. The cheapest and most efficient way was to erect a landing stage out in the sea at a point well clear of surf and rocks in a depth of water to permit large vessels to be independent of the tide, and to connect it with the mainland by an aerial cableway. There were no insuperable obstacles to the construction of the stage, and owing to the small base width required for carrying the supports of the wire ropeway, practically no resistance would be offered to the current running along the coast which might lead to deposits of sand and mud. Moreover, the carrying ropes constituting the connecting link with the mainland could be carried at a height to prevent their being reached and damaged by waves in the heaviest storms. The site selected was at a point in



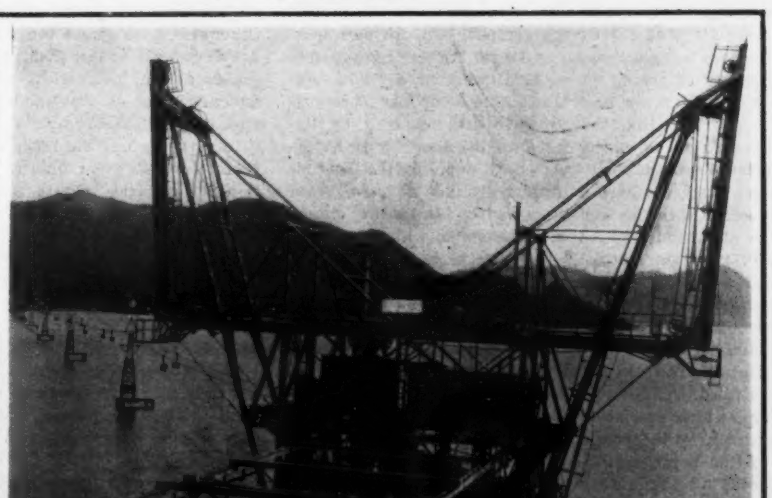
GENERAL VIEW OF LANDING STAGE, SHOWING DOUBLE-SIDED LOADING AND UNLOADING CRANES.



TYPE OF SUPPORTING TOWER ON SEA SECTION, SHOWING MASONRY FOUNDATION AT LOW WATER.

CENTRAL STATION OF PLANT FOR LOADING AND TRANSPORTING MINERAL ORE.

ORE-CARRYING VESSEL ANCHORED AT THE LANDING STAGE.



END VIEW OF CRANE AT TERMINAL OF SEA SECTION OF CABLEWAY.

AN INTERESTING AERIAL CABLEWAY AND ORE-HANDLING PLANT IN NEW CALEDONIA.

Mission Bay 3,500 feet from the shore. It was sheltered by a lofty precipitous peninsula, thereby enabling vessels to anchor in perfect safety. The hinterland on which ore depots were established, and the railroad station communicating with the mines inland, were situated at such different altitudes that a connecting surface railroad between the two would have been too expensive, and transference of freight into various types of vehicles would have been unavoidable. Also, as this depot was the principal point for collecting the ore, cargoes brought over in small steamers from the mines on the surrounding islands would have to be discharged and then reloaded into larger ocean-going craft. Again, in order to secure a necessary high tip, an aerial cableway would have had to be installed for the formation of ore banks 65 or 70 feet high, so in order to facilitate the whole scheme of transport, a comprehensive overhead system was adopted. The undertaking was placed in the hands of the well-known Leipzig engineering firm of Adolf Bleichert & Co.

Some idea of the work this cableway does may be gathered from the fact that it has to discharge ballast or coal from incoming vessels; unload the small coastal craft bringing ore from the surrounding islands and dump it on the collecting banks; transport the ore brought by railroad to the depot or discharge it into waiting vessels moored alongside the landing stage; transfer coal previously brought from vessels to the coal depot and thence into other ships; and finally negotiate the passenger and freight traffic between the landing stage and the mainland. The heaviest and most important work, however, is the loading of vessels with ore.

The whole plant is a rope-driven suspension railroad. The central station is located at the point where the various sections unite, so that the driving movements can be directed to the separate places of operation. It lies close to the sea near the terminus of the trunk railroad coming from Bornet, which line runs with a moderate gradient on to a bank at such a height that the wagons can be emptied through bottom flaps into large hoppers standing at the head of the bank. Beneath these hoppers are situated the terminus of the aerial cableway which branches off in various directions to the landing stage, and the ore and coal depots. Receiving their charge of ore from beneath the hoppers the cars of the cableway are carried over lofty steel supports to a return station where they automatically turn and run back to a point near the railroad station where the ore is dumped. Above the ore depot movable abutment appliances serve to tip the cars and so discharge their contents without interruption in the traffic. As this ore amounts to some 50,000 tons, it was necessary to tip to a height of 65 feet, so that the supports of the cableway, 80 feet in height, will be buried in ore up to the protection rollers of the carrying ropes. To prevent these supports being damaged by the falling ore, cone-shaped supports of strong sheet metal were used. This prevents the clayey ores settling between the constructive parts, while the supports are not bent by the pressure of the ore bank. Ores intended for transportation to vessels are carried through to the landing stage and discharged into traveling hoppers, from which in turn the buckets served by the loading cranes are filled and emptied into the ships, while the cable cars turn automatically and run back to the central station. Another line, a double rope cableway, runs alongside the ore tip at the low height of about 8 feet, joined up to a traveling cross bridge, which spans the whole tip at a height of 8 feet and carries two hoppers from which the low-level suspension cars are filled. This is effected by means of two cup elevators, which run alongside the tipping place on rails, and convey the ores to the cross-bridge hoppers.

After being charged, the overhead cars travel an ascending grade to a junction, rising from about 8 feet to 33 feet, where through switches and cross-overs, communication is gained either with the sea-going section or that extending to the coal depot of 1,500 tons capacity. The whole system is divided into four sections. Line 1 conveys ore from the hoppers of the central station to the ore depot, the capacity of which is 40 tons per hour. The cars on this length have a speed of 6.5 feet per second, and are spaced 396 feet apart. Line 2 extends from the central station out to the landing stage, and forms the most important stretch of the whole system, since all communication with the sea station passes over this section, whether it be ore, passenger and freight traffic, or water, provisions, etc., for vessels. This line has a capacity of 100 tons per hour, a car speed of 6.5 feet per second with 178 feet between the cars. Line 3, of the same capacity, car speed, and distances between the cars, carries the ore from the depot on the low-level cableway to either the central or sea station. Line 4, the low-level section, conveys ore from the depot to line 3 for transference to the sea station, and has a capacity of 100 tons per hour with a car velocity of 26.4 feet per second, with a distance of 72.6 feet between the cars.

In loading a vessel with ore, three supply lines are brought into operation simultaneously. The cargo can be brought direct from the railroad station, or from the ore depot by either the line 3 or low-level line 4. All traction ropes are put in motion from a single common station situated at the extreme point of the coal-tipping bridge. Power is supplied from a twin-cylinder steam engine running at 130 revolutions per minute, and which with 27 per cent admission develops 30 horse-power, increased to 50 with 50 per cent admission. In the system a large number of curve returns have had to be negotiated automatically without detaching the cars from the traction rope, since if such were done, interruptions in traffic would arise, owing to the comparatively rapid sequence of the cars. Moreover, as there are four different traction ropes driven for various purposes, they have all to work together in such a manner that the cars can be transferred from one line to another quickly and easily. In such a case, with four traction ropes subject to varying tensions, the importance is obvious of having some system to neutralize the disadvantage of various rope diameters arising through wear without involving the necessity of adjusting or altering grips. All traction ropes have a uniform diameter of 0.6 inch, but this does not remain constant, owing to the wear and tear. To obviate this, the Bleichert automatic gripping apparatus with underhung rope has been adopted, which admits gradients up to 45 per cent, and is at the same time completely insusceptible to variations in rope diameter, gripping as it does a worn rope of 0.44 inch with the same power as one of 0.6 inch diameter.

For the sea-going line and that over the ore depot, the suspension cableway track is in locked carrying ropes with a long span. The ore depot spans are consecutively 207.9, 231, 181.5, and 165 feet while, on the sea section, the distance between supports is 369 feet. Otherwise, throughout the whole plant the well-known double-headed suspension rails with a height of 6.4 inches and a head width of 1.6 inch are employed, and are hung at a suitable height by means of cast-iron suspension shoes on a portal-like framework.

In carrying out the land portion of the undertaking there were no great difficulties, but with the sea section serious ones had to be overcome. The shore at first is rocky and tolerably level, but farther out muddy and unstable, so that the selection of suitable foundations proved no easy task. At the same time, it was imperative that the landing stage should be placed sufficiently far out to insure a minimum depth of 33 feet for vessels at all times. The foundations for the landing stage were carried out on novel lines. The rough character of the sea and the muddy bed rendered it impossible to wall up the posts under water with the aid of divers; while piling under air pressure was somewhat doubtful of success. It was therefore decided to assemble the pile planking for inclosing the cement pillars during erection to a certain extent on shore, and then to take them out to sea and sink them in position. The site was dredged, and mud removed until firm ground was gained. Upon this was placed a layer of heavy stones to a depth of 10 or 13 feet, partly to afford a firm foundation for the piers, and partly to prevent the dredged site from being overloaded with mud. The caissons were made of two timber cylinders, an inner of 33 feet and an outer of 46.2 feet diameter. These cylinders or tuns were built on slips on shore. First the floor was made and then the iron frame erected, around which planks were secured. The cylinder was made absolutely water tight. The tuns were launched and towed to the erection site, where they were sunk by the admission of water.

The supports for the sea section of the cableway were also equipped with substructures, though it was found sufficient to drive piles into the soft seabed, and to build cement piers on ledges inshore. This was accomplished by divers by erecting pile planking and filling with cement under water.

The aerial track and landing stage are electrically lighted. This stage is composed of two parts meeting on the central pier, each about 115.5 feet in length, the clear span length being 97.35 feet. Each section consists in turn of two main carriers, 10 feet high and 36.3 feet apart. Carrier cords take up the rails for the traveling cranes, and means are arranged to allow play for the landing stage, for bracing the working platform and suspension cableway, and for taking up the suspension cableway shoes. This platform lies about 7 feet above the upper cord of the main carriers, alongside of which runs a second platform, which serves for attendance upon the traveling cranes. The landing stage on the land side has an extension which carries the saddles for the carrying ropes of the ropeway and its tension weight rollers.

The drive of the cableway is effected from the central station on shore. The rails of the suspension cableway, on which the cars are moved by hand on the landing stage, join up with the through line, several switches and short sidetracks being provided on the landing stage, to obviate the necessity of the cars traveling its whole length when not requisite.

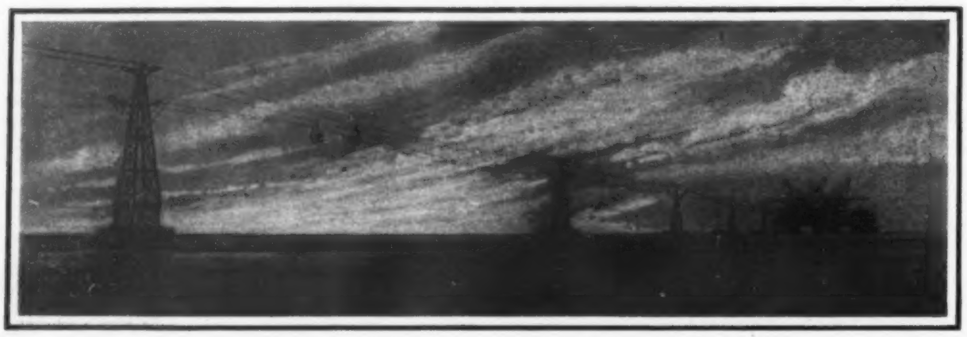
The two cranes traversing the landing stage are of a double jib type with two rope trolleys which permit hoisting, lowering, and stopping at any point of the track, and both serve the suspension railroad on either side with equal facility. They carry a platform just over the superstructure upon which is placed the engine house, the cranes being steam driven. Owing to the high measurements of the cranes, an extreme degree of stability, especially against wind pressure, had to be secured. By an arrangement of the engine cabins, it is possible for the cranes to run with their jib sides close together and to joint them by special anchorages. They then form a construction that can preserve its stability in the heaviest storms. The outer parts of the jibs can be raised, to enable ships to moor alongside without cross towing.

The cranes can be operated with both grabs and buckets. These grabs can be changed for buckets without taking out the hoisting ropes, as frequent changes from grabs to buckets and *vice versa* are necessary. For use in raising the jib, two winches are driven by the engine of the main winch by Ewart driving chains. From the winches the wire ropes pass over the end of the fixed jib frame to the extremity of the movable jib, which is held in its level position by joint rods. For the purpose of traversing the landing stage, each crane is provided with four hand-driven devices.

In dealing with loading work, each crane is provided with four hoppers and charging funnels. The cars arriving from the shore discharge their contents into these funnels. The lower funnels are fitted with chutes, through which the ore gravitates into the buckets hanging in the traveling trolley, and are run out over the hatchway of the ship and tipped. In unloading vessels, the discharge chute of a further hopper fills the cableway cars without difficulty, and they are sent loaded to the shore. The flap-locks of all the chutes are worked from the driver's cabin, while a large indicator records all motions of the trolley and the buckets.

Several operations may be carried out at the same time. Two ships at least can be loaded or unloaded simultaneously, or one ship can be loaded with ore while another on the opposite side of the stage can discharge coal or ballast. The cableway over the sea has a capacity of 100 tons per hour either way. The capacity of each crane is 100 tons ore loading, and 60 tons sand and 40 tons coal unloading, per hour, respectively. Mixed freight can be unloaded with complete facility by switching.

The total length of the cableway, including the various sidetracks, branches, and returns, approximates 8,250 feet, and over 2,000 tons of iron and steel have been worked in its construction. The capacity of the plant is seen in the fact that ships of 3,000 tons, which formerly required from 20 to 60 days to load or unload their cargo of ore, can now be handled in three or four. What is possibly more remarkable is the displacement of manual labor. Formerly the loading of a ship required the efforts of two or three hundred workmen with a large fleet of barges to convey the ore from the shore to the ship or *vice versa*. With



GENERAL VIEW OF SEA SECTION OF LINE AND LANDING STAGE.

this plant, including the operation of the whole crane installation, only some fifty hands are necessary.

The plant, despite its large proportions and the difficulties, was completed in the remarkably short time of five years. By the fulfillment of this undertaking, the remote island of New Caledonia is provided with one of the largest, most efficient, and economical transportation and loading plants in the southern hemisphere, and the facilities thus provided for shipping the nickel, copper, cobalt, antimony, and other mineral ores existing on the island will result in a striking advance in its development.

HEATING THE FARM HOUSE.

METHODS OF OBTAINING WINTER COMFORTS.

THE desirability of fitting the farm dwelling with good plumbing fixtures, and of installing a modern lighting system and economical heating appliances, is beginning to be appreciated by the prosperous farmer of to-day. There is no reason why he should not enjoy the advantages and comforts of these improvements, just as the town dweller does. Many modern farm houses are arranged not only with an up-to-date kitchen and laundry, but also with a bathroom; moreover, many farm buildings are lighted by gasoline gas machines or by acetylene generators. A further improvement, greatly to be desired, is to render them comfortable and healthful during the winter by heating them with a hot-air furnace, or else by means of a steam heating or hot-water heating apparatus.

Owing to their usually exposed location, farm houses are difficult buildings to heat. The amount of coal or other fuel consumed in heating such a home will depend upon the climate, the locality of the dwelling, the extent of its exposure, the efficiency of the heating apparatus, and the care and economy in connection with its use. At the outset, attention should be called to the fact that heating the air of living rooms to a temperature of over 70 deg., as is so often the case in American dwellings, is enervating, and that we should accustom ourselves to be comfortable at an average temperature of about 68 deg. The farmer who spends most of his time out of doors in winter will find even this degree of heat uncomfortable indoors.

The ventilation of the farm house should not be overlooked, being closely connected with the subject of warming. In burning coal, wood, oil, or gas, undesirable and often poisonous gases are given off, and the air of rooms becomes contaminated with them, where stoves, furnaces, or other heating appliances are not correctly constructed, or where the fire is not properly managed. It is necessary that all objectionable gases of combustion be carried off by a suitably constructed chimney flue. The heating plant should be of such dimensions and capacity as to do the work required of it readily even in the coldest weather. The overheating of stoves or furnaces when driven beyond their capacity is to be guarded against.

An open fire-place always constitutes a cheerful feature in a comfortable farm house, and it also helps to provide good ventilation, but unfortunately most of the heat given off by the blazing logs is wasted by passing up the chimney. The warmth from such a fire is imparted to surrounding objects or persons by direct radiation and without warming the surrounding air to any great extent, hence it often happens that in cold weather a person standing near the fire feels the warmth excessively, while at the farther parts of the room the heat is scarcely perceptible. Another drawback is, that the heat is felt only on the side of the body nearest to the fire, the other side remaining cold. Various types of open grates have been devised with a view of saving a portion of the fuel which in the ordinary fireplace is wasted. The so-called "ventilating fireplaces" are provided with a large chamber to which air is supplied from out of doors, the fresh air being thus heated before entering the room.

For heating small rural dwellings, the usual and most economical means are stoves, made either of cast or of wrought iron, and burning either wood or coal. There are many good makes on the market today. Where stoves are used for warming rooms, plenty of fresh air should be admitted, even though an occasional draft may be inconveniently felt and the temperature be slightly reduced, for in the case of stoves, practically none of the vitiated air of a room is removed by the chimney flue. Since comparatively little fuel is consumed, stove heating appears to be economical, but in general, the results obtained as regards comfort and health are far from what they might be if a hot-air furnace or a steam or hot-water heating apparatus were installed. The larger the farm house, the more work will be entailed in attending to the stoves, carrying coal or wood to them and removing the ashes.

Stoves are sometimes constructed to burn oil or gas as a fuel. Gas stoves are convenient for heating or cooking, but they can only be used where a farmhouse has a gas supply available, which is very rarely the case. Gas stoves and gas logs are rather expensive heating appliances, and the gases given off in combustion vitiate the atmosphere to a considerable extent, hence flues should be provided for drawing them off. Used as exclusive means of heating, such stoves are expensive to run, and therefore not to be recommended.

Gasoline stoves may be used in combination with a gasoline lighting system. The gasoline is usually supplied by gravity from a tank overhead. These stoves are more often used for cooking than for heating. Oil stoves give off an abundance of heat and present the advantage of portability, but they give off the odor of burning oil, which to many people is obnoxious. There is usually no smoke-pipe connection, and they have the further drawback of requiring frequent filling and cleaning. They are, however, inexpensive, require no setting and the fuel costs little. Being portable, they can be carried from one room to another, just where heat is most wanted.

For farm houses the ordinary stove using coal as fuel is much preferable to stoves using gas, gasoline, or kerosene oil. It is essential that a coal stove should be well built, that it should have tight joints, and that it be lined on the inside with fire brick to prevent a possible overheating. Stoves should be set on stone or sheet iron, never on wood, as this might involve danger from fire. All coal stoves should be provided with a large smoke pipe and damper; a jacketed inclosure with fresh-air inlet is also desirable, together with a device for regulating the amount of fresh air admitted.

Warm-air furnaces consist essentially of a large stove set within a casing, air being admitted between the two. As the air becomes heated it ascends and passes through the hot-air ducts into the rooms to be heated. The main parts of a furnace are the ash pit, the fire pot, the combustion chamber, the radiator, and the outer casing. Then there is also a grate, an evaporating pan, and generally a dust flue. It costs less to install a furnace with the necessary hot-air pipes and registers than to put in a modern hot-water or steam-heating apparatus.

The furnace should be placed in the cellar and located near the center of the building, or slightly toward the side which is apt to be exposed. There should be a cold-air box to supply fresh air from this side of the house. The draft of the furnace depends upon the chimney flue, which should be constructed in the best possible manner, so as to be practically tight. There should be no other openings in, or registers connecting with, the chimney flue.

The smoke pipe leading from the furnace to the fire and the hot-air flues conveying the heated air to the registers, should both be as short as possible and free from unnecessary elbows or bends. Floor registers are preferable in the lower rooms to wall registers from an economical heating standpoint, but the best air circulation is no doubt maintained where there is a hot-air register situated high up on the wall of each room to be heated, and a vent register connecting with a vent flue on the same wall low down near the floor. Registers placed in the floor are also insanitary because they are apt to collect a good deal of house dust.

The advantages of furnace heating are the low initial cost of the apparatus, the fact that only one fire is to be looked after, and the further fact that pure fresh warm air is supplied, provided a proper fresh-air inlet and cold-air box have been installed. The rooms are not encumbered with stoves or defaced with large, ugly radiators, and the temperature can be regulated to a nicety by means of a damper regulator. The furnace ordinarily requires only moderate care and attendance, for looking after it two or three times a day is usually all that is necessary, and the labor involved in carrying coal and removing ashes is much less than with stove heating.

One of the essential points in the care and management of a furnace—and for that matter of stoves—is to know how to check the draft by means of the damper and the slides in the furnace doors. Ignorance regarding the proper checking of the draft has often resulted in the escape of sulphurous gases, where the damper has been turned on too soon, or of carbon dioxide, which is poisonous and a menace to health, where the damper is turned so that the draft is reduced too much. With a little intelligent attention and care neither of these gases will be found to enter rooms in quantities sufficient to be objectionable.

Furnaces are made of cast iron, wrought iron and steel plate, and for each of these materials some advantage is claimed. Then there are two general types of furnaces, known as the direct-draft and the indirect-draft types. In the former class, which comprises the greater number, the gases pass through a radiator located in the upper part of the furnace above the combustion chamber before reaching the smoke pipe. There is but one damper, which is generally combined with a cold-air check. In the ordinary indirect-draft type of furnace, the gases pass downward through flues to a radiator which is located near the base of the furnace, and then pass upward through another flue to the smoke pipe. These furnaces have a damper in the smoke pipe and also a direct-draft damper, which is intended to prevent the escape of gas.

The size and the kind of grate installed in the furnace are of great importance to the user, because on them will depend the economy of the furnace and to some extent the size and kind of coal which he will have to purchase. Some furnaces are built for burning soft coal, natural gas, or even wood in districts where hard coal is more expensive than other fuel.

Furnace heating is disliked by many, on the ground that it is injurious to health, principally because it dries the air of rooms unduly. While it is true that improperly-designed or constructed furnace apparatus may cause headaches or illness, it is not reasonable to condemn all furnaces on this account. For those who dislike the dry air of the furnace there remains the choice of a steam-heating or of a hot-water heating system, and our next article will deal with the relative merits of these systems.—Country Gentleman.

GOLD MIRRORS FOR SEARCHLIGHTS.

THE recent R. A. C. tests on motor car headlights have brought prominent before both motorists and the public generally the importance of road illumination both from the point of view of the motorist and of other users of the road. There has been considerable outcry against the use of powerful headlights showing a white blinding "glare" or "dazzle." It has always been taken for granted that the whiter and the more powerful the light, the more perfect the illumination obtained. This, however, is by no means the case, for it is well known that the rays of low refrangibility, i. e., the red and yellow rays, are far less absorbed by the atmosphere than the violet rays. A well-known example of this is the comparative penetrative power of gas and of the electric arc in a fog, the high-candle-powered arc lamp being visible at a shorter distance than the gas light. Again the red color exhibited by the sun at its setting is also due to the fact that the violet rays are largely absorbed by the greater thicknesses of atmosphere which must be penetrated by the sun's rays. To achieve these results a long series of experiments have been made with glass mirrors coated with gold instead of the usual silver deposit. The resulting beam of light is practically devoid of the blue and violet rays of the spectrum, being composed of red, yellow, and green rays only. At the same time its range of penetrative power is not reduced and from the elimination of the violet rays, the dazzling effect is greatly reduced. In the recent R. A. C. tests the only three lamps fitted with gold reflectors secured the first three places for maximum distance from lamps without dazzle. For naval projector work it is found that a torpedo boat on a foggy or rainy night can be more clearly seen with a gold than with a silver mirror projector. The objects illuminated stand out more prominently and there is truer color rendering.—The Steamship.

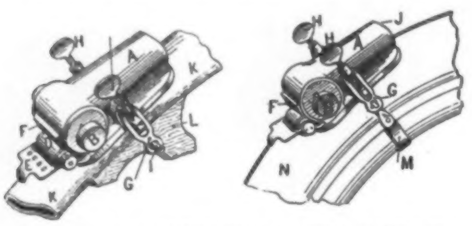
The construction of a mono-railway through Pelham Park to City Island will be commenced in a short time. Engineers of the Public Service Commission, who saw the system in operation at the Jamestown Exhibition, say that a speed of 135 miles an hour may be expected over parts of the route where right of way has been granted away from highways, so that the train headway may be unrestricted. If this line meets with the approval of the public, application will be made for permission to operate mono-rail express trains on an upper deck ever the present elevated railways in New York.

INVENTIVE NOVELTIES.*

SOME SIMPLE PRACTICAL INVENTIONS.

AUTOMATIC VULCANIZER FOR AUTOMOBILE TIRES.

In order to repair a pneumatic tire, in an effective and durable manner, it is necessary to employ the process of vulcanizing, in which natural or unvulcanized rubber and sulphur are heated together to 275 deg. F. for half an hour. Both the time and the temperature must be carefully regulated, in order to insure that the rubber shall be perfectly vulcanized but not burned or overheated. This regulation is effected automatically by the vulcanizing apparatus "Vulcana," here described and illustrated. The body of the apparatus is a hollow block of aluminium, *A*, the base of which is curved to fit the air tube (Fig. 1) or envelope (Fig. 2) of an automobile tire of average size. For repairing an air tube the vulcanizer is attached



Figs. 1 and 2.—AUTOMATIC VULCANIZER.

by two stirrups, *G H*, to a piece of hard wood, *L*, which fits the concavity of the air tube (Fig. 1). For repairing an envelope the apparatus is applied directly to the inflated tire and secured by the stirrups and a strap, *M* (Fig. 2). Inside the aluminium case is a copper tube *B*, which contains a cotton wick saturated with alcohol. The vulcanizer being inclined, as shown in the illustrations, sufficient draft is maintained in the interior by means of the orifices *F* and *J*, through the former of which the alcohol is lighted. The quantity of alcohol in the little lamp *B* is just sufficient for complete vulcanization and, when this is effected, the lamp ceases to burn. It is necessary, however, to regulate the combustion so that the temperature shall never exceed 275 deg. F. This regulation is accomplished by a perforated shutter, *E*, which automatically closes and diminishes the draft on the attainment of the desired temperature, which is then maintained for half an hour. The shutter is closed upon the orifice *F* by a spring, but in the first part of the operation it is kept open by a small piece of metal contained in the box *D*. This metal fuses at 148 deg. F., which temperature is attained in the box *D* when the temperature of the vulcanizer exceeds 275 deg. F. When this occurs, therefore, the metal fuses and releases the shutter, which closes and reduces the combustion to an amount just sufficient to maintain the temperature unchanged.

For the next operation the shutter is opened by hand, for it turns, with considerable friction, on its axis, which remains fixed in the solidified metal.

This simple and ingenious device, being made chiefly of aluminium, is very light and measures only about 4 inches each way, so that it can be carried and used on the road. The repairs are made with solutions of India rubber mixed with flowers of sulphur, or with sheets of soft rubber.

WRENCH WITH INTERCHANGEABLE DISKS.

The Schroeder wrench, Fig. 3, is a new tool which may be applied to bolts of different sizes and should be very useful to automobilists, who are compelled either to carry a large assortment of simple wrenches or to struggle with the grave defects of the monkey wrench. At each end of the Schroeder wrench is a large circular opening which may be fitted with any one of a series of movable disks or rings, having hexagonal openings of various sizes. The edge of each disk bears inclined

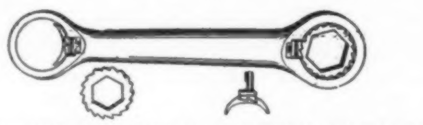


Fig. 3.—WRENCH WITH INTERCHANGEABLE DISKS.

or ratchet teeth which engage with a spring catch on the wrench and thus keep the disk in place. The disks can be changed by drawing back the catch, pushing out one disk and inserting the other. A set of disks is very much lighter and less bulky than a corresponding set of simple wrenches. The implement is operated, like a ratchet wrench, by an alternating motion of the handle, the catch engaging with the teeth of the disk when the handle is turned one way and slipping past them in the return movement. This is a great advantage, especially for operating in confined spaces.

Fig 4.—WRENCH WITH TUBE FOR OPERATING IN CORNERS.

For turning nuts very difficult of access, the tubes illustrated in Fig. 4 are provided.

DRAGON FLY BOOMERANG.

The dragon fly boomerang is a new and very interesting, though exceedingly simple, toy. It consists of a rod of celluloid of about the dimensions of a lead pencil, to one end of which are attached two propeller blades of the same material. If the rod is rolled between the hands, as shown in the illustration, the propeller may be rotated with sufficient velocity to lift the apparatus and enable it to fly through the air. The character of its flight depends on the manner in which it is held and thrown. If the upper end of the

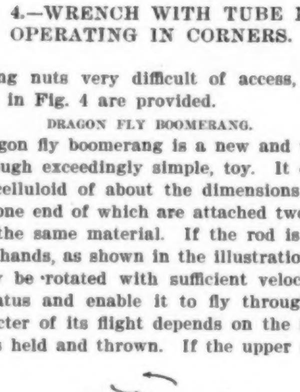


Fig. 5.—DRAGON FLY BOOMERANG.

rod is inclined toward the operator, and the hands are thrown forward at an angle of 45 degrees, at the instant of release, the dragon fly advances from 4 to 5 yards, according to the force with which it is thrown, before its forward motion is destroyed by the resistance of the air. Its rotary movement continues still longer, and the result is that the toy glides down an inclined plane of air, and returns to the hands of the thrower. This flight is very similar to that of a boomerang. When two persons play with the dragon fly it is inclined away from the thrower and is thrown forward horizontally toward the other player, who catches it on the wing and returns it in the same manner. In this case the flight may extend to 7 or 8 yards. Vertical flights of considerable height are accomplished by holding the rod exactly vertical while it is being spun. (See Fig. 5.)

HOUSEHOLD LAUNDRY APPLIANCES.

The employment of properly constructed washing

Figs. 6 and 7.—WASHING MACHINES.

machines saves clothes as well as time, labor, and fuel, for the rubbing and beating practised in washing by hand, with the aid of washboards and beetles, are very destructive of linen and buttons. A simple washing machine (Fig. 6) consists of a wooden tub, in which a perforated blade or shutter is turned, by hand, round a vertical axis. In this way the clothes are moved through the soapy water and pressed against the side of the tub. Most of the impurities are removed in five or ten minutes. The clothes are then washed in clean soap suds and, finally, rinsed in water, both operations being conducted in the same machine.

Another washing machine (Fig. 7) is a rectangular wooden vessel, lined with zinc and provided with a tightly-fitting cover and a number of partial partitions or cross-pieces. The vessel rests on horizontal bearings on which it is rocked by means of a handle. The clothes are first boiled with soap and then placed in the machine with a hot solution of soap and carbonate of ammonia or soda. After 15 minutes' rocking, the liquid is drawn off and replaced by pure water. A brief additional rocking leaves the clothes thoroughly cleaned. The operation of this machine is not laborious if the vessel is well balanced on lubricated bearings. For 100 parts by weight of dry clothes 8 or 9 parts of soap and 3½ parts of carbonate of soda should be used.

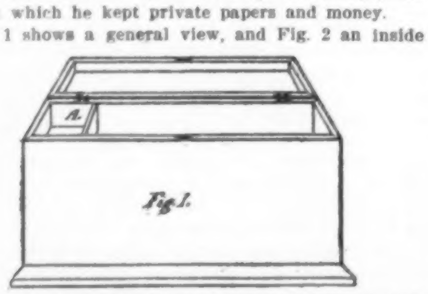
Carbonate of soda should not be used on colored or woolen goods, and the latter should be washed in moderately hot, but not boiling, water. The clothes wringer, in which the clothes are pressed between two rollers covered with India rubber, is too well known to require either description or recommendation. A convenient device for drying clothes indoors consists of a light rectangular frame of bamboo, strung with a number of clothes lines, and suspended from the ceiling of the kitchen or laundry by an ingenious system of cords and pulleys, by which it can be easily lowered to a convenient height and, after receiving its load of clothes, can be raised to the hottest part of the room, near the ceiling, where it and its burden are out of the way. The frame can be taken apart for storage or transportation.

* From La Nature.

A BOX WITH SECRET DRAWER AND RECESSES.

This box was made by an old carpenter, many years ago, in which he kept private papers and money.

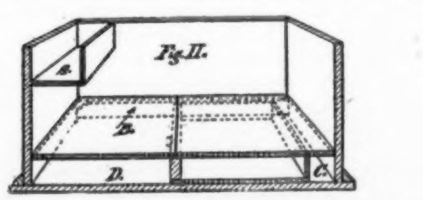
Fig. 1 shows a general view, and Fig. 2 an inside



view of the box, the lid and front being removed. Both views are shown in perspective. The material from which the box is made is ¼ inch thick for the top, bottom, and sides, and ⅛ inch thick for the drawer, false bottom, and lidless box to the left, marked *A*. The sizes are 6 inches deep, 6 inches wide, by 12 inches long, outside dimensions. The box was made in the usual manner, by nailing up solid, and then cutting out the lid 1 inch from the top. Referring to the sectional view, Fig. 2, the false bottom is made in two parts, one of which is nailed to the two strips of wood marked *B* (one of them not shown). The other half of the false bottom is loose, and rests upon these two strips. As will be seen, one end of them is chamfered so that when pressure is brought to bear upon the end of the false bottom under the box *A*, it will tilt up and can be taken out.

The drawer is made of such a size that it will just clear the opening thus made, without the knob, which must of necessity be removed, this being one of the secrets to get at the recess *C*. The knob is an ordinary screw knob. The front of the drawer is made of ⅜-inch stuff. A piece of felt, or cloth, the exact size of the inside of the box is glued down to the fixed half of the false bottom, and left loose over the other half. The bottom of the box, *D*, is 7 inches wide, 13 inches long, by ¼ inch thick, the corner pieces of molding being ½ inch. The box is furnished with lock and hinges, and was nicely varnished inside and out.—American Carpenter and Builder.

Destruction of Vermin on Poultry.—Wendelen recommends as exceedingly effective a mixture of lime and



sulphur, mixed each week with air-slaked lime mingled with finely slaked coal ashes. The hens like to dust themselves in this mixture and are thereby freed from vermin.

BERJONNEAU SYSTEM OF TELEPHOTOGRAPHY.

A NEW FRENCH SYSTEM.

BY OUR PARIS CORRESPONDENT.

Among the new apparatus which have lately appeared for the transmission of photographs at a distance, we may mention the device which has been constructed at Paris by M. Berjonneau and experimented with over a short distance of line with very good results. The accompanying diagrams show a view of the transmitter and the receiver of the Berjonneau apparatus. As to the transmitter (Fig. 1) which will be seen in the upper part, its construction is of a very simple character. The copper sheet which contains a half-tone impression on its surface is rolled around the cylinder *C*. The cylinder and the remainder of the movement are taken from an ordinary phonograph, as we have here all that is necessary to make the contact point pass successively over all the points of the half-tone. Next to the cylinder is the arm *A B* which

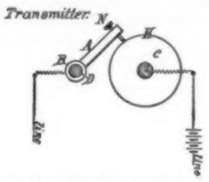


Fig. 1.—TRANSMITTER OF THE BERJONNEAU APPARATUS.

is mounted in the usual way upon the screw shaft *D* (see also side view Fig. 2). On the end of the arm is mounted the contact needle, which is simply a steel point, or an ordinary needle can be used. In this way we have the same movement over the surface of the cylinder as we find in the phonograph, except that the stylus of the phonograph diaphragm is replaced by the contact needle. The half-tone is made upon a very thin copper sheet, about 1/100th or 1/150th inch in thickness, and the sheet is rolled tightly around the metal cylinder. However, it is not wrapped all the way around, as it is desired to leave a certain space on the cylinder, say ½ inch, in order to provide for the synchronism of the motor. The cylinders of the transmitting and receiving stations are each driven by a synchronous motor at practically the same speed. It is found that an ordinary half-tone plate has a disadvantage for this method, which comes from the fact that it presents a series of projections and hollows, so that the needle would be obliged to travel over a rough surface. This the inventor wished to avoid. In the formation of the half-tone plate, we have a copper plate which is covered with a bichromatized gelatine film. When this is acted upon by light passing through a negative plate and also through the usual screen composed of parallel vertical and horizontal ruled lines on a transparent surface, the sensitive surface receives the impression in the form of dots which are separated by transparent spaces. Upon washing the gelatine surface, the parts which are unacted upon by the light are dissolved off, and thus in the white portions there are very small gelatine dots separated

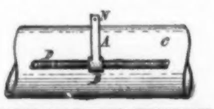


Fig. 2.—SCREW SHAFT ON WHICH IS PLACED THE TRANSMITTER ARM.

by a relatively large surface of copper which is now exposed. In the blacks nearly all the surface is covered by the gelatine. To make the halftone for printing, the plate is now etched in an acid bath so as to give raised surfaces. But for the present purpose the plate is used before it is etched, and it thus has a perfectly smooth surface so that the needle can pass over it with ease. Where the needle encounters the gelatine, the current is broken in the line, seeing that one pole of the battery is connected to the copper surface and the other to the needle. The current is interrupted for a longer time in the blacks, seeing that the gelatine predominates here, while in the whites it is the copper or conducting surface which has the larger proportion. Such a series of currents sent into a suitable apparatus at the receiving end can be translated into an image which corresponds exactly with the former. It will be noticed that M. Berjonneau's apparatus differs from the others which we mentioned above from the fact that he uses a succession of contacts or an interrupted current in the line instead of a current which is varied in amount by means of a resistance. Here it is the duration and not the value of the current which causes the effect in the receiver, for the current itself remains constant.

This interrupted current is translated into the corresponding image by means of the receiver which is shown in the diagram (Fig. 3). Here we have a cylinder *C'* and its sliding arm *A' B'* which are of the same form as those of the transmitter, and a given point in the arm is thus made to cover the surface of the cylinder at exactly the same rate as in the transmitter. Upon the cylinder is wrapped a sheet of sensitive paper. For this purpose bromide paper is the most practical to use, as it is easy to procure and to put in place. To protect the paper from the action of the light, the cylinder is surrounded by a hollow cylinder of sheet metal *T*, leaving a slot along the entire length at *t*. The slot is kept closed at all points except at a small opening which is just opposite the middle of the arm. Through this hole is sent a beam of light from the receiving apparatus which can make an impression upon the paper which is variable according to the current sent over the line.

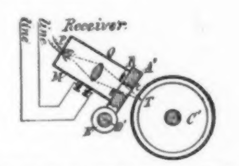


Fig. 3.—RECEIVER OF THE BERJONNEAU APPARATUS.

Upon the sliding arm is mounted the *ensemble* of the receiving parts which cause the variations in the beam of light, and these parts are all contained in a compact metal case *M*; they are of light weight so that they can be carried upon the sliding arm and move together with it while the cylinder revolves. In this way the beam of light is made to cover the whole surface of the cylinder so as to give the image. On the inside of the box *M* are placed an incandescent lamp *P*, a lens *Q*, and an electro-magnetic shutter *R*. The lamp is connected with a suitable source of current by means of a light flexible cable. Its light, concentrated by a concave mirror, is sent through the lens, and the latter is adjusted so as to bring the beam to a focus upon the sensitive paper of the cylinder. In order to interrupt the beam of light according to the current impulses in the line we have the shutter *R* placed in the path of the beam between the lens and the sensitive surface. By sending a current in the line, the shutter is opened, or on the contrary it is closed when there is no current, thus stopping off the light. This action will be noticed by referring to the diagram showing the detail of the shutter (Fig. 4). Mounted on a base *A'* there are two pieces of sheet iron *F F'* which can swing upon its pivots and are controlled by springs. At the middle point where the beam of light *l l'* passes the shutter there is a hole in the plate *F* which can be covered or uncovered by the plate *F'* according to the position of the two plates. The last are controlled by the corresponding electromagnets *E E'*, so that when a current passes in the line it is received by the magnets and causes the hole in *F* to be uncovered. This allows the beam of light to pass from *l* to *l'*, and at the latter point it falls upon the bromide paper, as we have seen above. In this way the short contacts made at the halftone of the transmitter and representing a dark portion, make a corresponding set

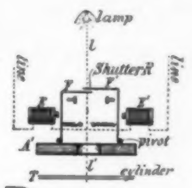


Fig. 4.—DETAIL OF THE SHUTTER.

of short exposures at *l'* while the cylinder passes, and we also have a dark part on the bromide paper, and *vice versa*. The shutter can be arranged in two different ways, according to whether the electromagnet causes the shutter to be opened or closed upon the passage of the current, so that we can obtain either a positive or a negative impression upon the sensitive surface. A celluloid film can of course be employed on the cylinder instead of the bromide paper, and it is necessary when it comes to making a negative impression. As here shown, the arrangement of the shutter is merely in diagram, and the actual shutter is more compact. Besides, it is not essential that the plate *F* should be moved, as the movement of plate *F'* can suffice for this purpose.

It is necessary to have some means of closing up the slot which is cut in the protecting screen, while the arm is passing along, so that the light will not enter the chamber except just in front of the arm at the point where the beam passes. This is done very simply, as shown in the diagram (Fig. 5). We have the cylinder *a* contained in the protecting box *b*, also of cylindrical form. Along the cylinder *b* is cut a slot *c* which runs over nearly the whole length of the inner cylinder. The beam of light *l l'* can take any position from *A* to *B*, passing through the slot. In order

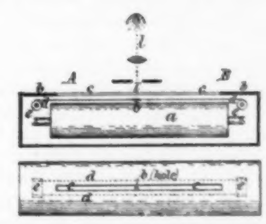


Fig. 5.—MEANS FOR CLOSING SLOT IN THE SCREEN.

to close off the latter, there is a strip of black cloth which is mounted between the rollers *e e* and carrying the hole *b*. The strip is moved so that this hole is always under the arm and in the path of the beam.

A MARINE STEAM TURBINE REDUCING GEAR.

Ever since the introduction of the steam turbine for ship propulsion numerous efforts have been made to improve the efficiency of turbines running at comparatively low speeds, in order to accommodate them to the most efficient propeller speeds. The result in nearly every case has been a more or less unsatisfactory compromise, since the turbine is essentially a high-speed engine, and its best efficiency and its lightest weight per horse-power developed can only be obtained at high speeds. To overcome this difficulty Rear Admiral George W. Melville, formerly chief engineer of the United States navy, has designed a reducing gear, to be interposed between the turbine and the propeller shaft, so that the turbine can run at a comparatively high speed, while the propeller shaft revolves at relatively low speed. According to the American Machinist the gear consists of a floating frame supporting two spiral gears of different diameters, the smaller of which is connected to the turbine shaft and the larger to the propeller shaft. An experimental gear of this type has been built at the shops of the Westinghouse Machine Company, Pittsburg, Pa., under the personal supervision of Admiral Melville and John J. Macalpine. It is designed to transmit 6,000 horse-power. The pinions are of steel, having a tensile strength of 90,000 pounds per square inch, and the gears are 22-inch face and 14 and 70 inches pitch diameter.

The pinions each have thirty-five teeth and the spur wheels 176, a hunting cog being introduced to equalize the wear. In order to secure comparatively noiseless operation a small pitch was necessary; the pitch in this case was made 1¼ inches, and the pitch helices were placed at an angle of 30 degrees with the axis of the shaft. One wheel and pinion have right-handed and the other pair left-handed helices, in order to eliminate end thrust on the shaft. The small pitch, of course, necessitated the use of broad teeth.

To reduce fires in the Arkansas national forest the United States Forest Service has made an agreement with the Kansas City Southern Railway whereby the latter will clear its right of way. The railway will remove inflammable material for 50 feet on each side of the track and burn over an additional 100 feet where necessary, the Forest Service to supervise the work and supply the tools. A telephone system for the use of the Forest Service will be built along the right of way.

"BAKELITE," A NEW COMPOSITION.—II.*

ITS SYNTHESIS, CONSTITUTION, AND USES.

BY L. H. BAEKELAND, SC.D.

Concluded from Supplement No. 1768, page 323.

I have tried all organic or inorganic bases which I could obtain readily. I have tried the hydroxides and carbonates of the alkali metals, the hydrates of alkaline earths, ammonia and its alkaline salts, hydroxylamin, organic amines, pyridine, carbamide, and other amides of weak acids; and the effect, with slight variations, is always about the same; it is quite natural, that for reasons of economy or expediency, I should prefer the commercially or more available bases.

I wish it distinctly understood that in order to obtain my technical effect I use the bases in relatively small quantities, say less than one-fifth of the amount which would be required to transform the phenol into phenolate.

If larger amounts of base be used, the results are technically much inferior; in fact the process changes gradually into such as give phenol-alcohols or compound condensation products of ammonia or amines with formaldehyde, all products very different from those I desire to make.

I have good reason to believe that in my process the bases only act as catalyzers and intervene only temporarily in the reaction. They seem to be expelled in free condition during the last stage of the process. For instance, if I use ammonia, I find this ammonia back in the free state in the final hard condensation product.

A careful study of the condensation process of phenols and formaldehyde, made me discover that this reaction instead of occurring in two stages can be carried out in three distinct phases. This fact is much more important than it appears at first sight. Indeed it has allowed me to prepare a so-called intermediate condensation product, the properties of which simplify still further my methods of molding and enlarge very much the scope of useful applications of my process.

The three phases of reaction can be described as follows:

First phase. The formation of a so-called initial condensation product which I designate as A.

Second phase. The formation of a so-called intermediate condensation product, which I designate as B.

Third phase. The formation of a final condensation product, which I designate as C.

As to the properties of each of these condensation products I can define them in a few words:

A, at ordinary temperatures, may be liquid, or viscous, or pasty, or solid. Is soluble in alcohol, acetone, phenol, glycerine, and similar solvents; is soluble in NaOH. Solid A is very brittle and melts if heated. All varieties of A heated long enough under suitable conditions will change first into B then finally into C.

B is solid at all temperatures. Brittle but slightly harder than solid A at ordinary temperatures: insoluble in all solvents but may swell in acetone, phenol, or terpineol without entering into complete solution. If heated, does not melt but softens decidedly and becomes elastic and somewhat rubber-like, but on cooling becomes again hard and brittle. Further heating under suitable conditions changes it into C. Although B is infusible it can be molded under pressure in a hot mold to a homogeneous, coherent mass, and the latter can be further changed into C by the proper application of heat.

C is infusible, insoluble in all solvents; unattacked by acetone, indifferent to ordinary acids, or alkaline solutions; is destroyed by boiling concentrated sulphuric acid, but stands boiling with diluted sulphuric acid; does not soften to any serious extent if heated, stands temperatures of 300 deg. C.; at much higher temperatures begins to be destroyed and chars without entering into fusion. It is a bad conductor of heat and electricity.

The preparation of these condensation products A and B and their ultimate transformation in C for technical purposes constitute the so-called bakelite process. This can be described easily:

I take about equal amounts of phenol and formaldehyde and I add a small amount of an alkaline condensing agent to it. If necessary I heat. The mixture separates in two layers, a supernatant aqueous solution and a lower liquid which is the initial condensation product. I obtain thus at will, either a thin liquid called Thin A or a more viscous mass, Viscous A, or a Pasty A, or even if the reaction be carried far enough, a Solid A.

Either one of these four substances are my starting materials and I will show you now how they can be used for my purposes.

If I pour some of this A into a receptacle and simply heat it above 100 deg. C., without any precaution, I obtain a porous spongy mass of C. But bearing in mind what I said previously about dissociation, I learned to avoid this, simply by opposing an external pressure so as to counteract the tension of dissociation. With this purpose in view, I carry out by heating under suitably raised pressure, and the result is totally different.

This may be accomplished in several ways but is done ordinarily in an apparatus called a bakelizer. Such an apparatus consists mainly of an interior chamber in which air can be pumped so as to bring its pressure to 50 or better 100 pounds per square inch. This chamber can be heated externally or internally by means of a steam jacket or steam coils to temperatures as high as 160 deg. C. or considerably higher, so that the heated object during the process of bakelizing may remain steadily under suitable pressure which will avoid porosity or blistering of the mass.

For instance, if I pour liquid A into a test tube and if I heat in a bakelizer at say 160 to 180 deg. C., the liquid will change rapidly into a solid mass of C that will take exactly the shape of its container; under special conditions it may affect the form of a transparent hard stick of bakelite. It is perfectly insoluble, infusible, and unaffected by almost all chemicals, an excellent insulator for heat and electricity and has a specific gravity of about 1.25.

It is very hard, cannot be scratched with the finger nail; in this respect it is far superior to shellac and even to hard rubber. It misses one great quality of hard rubber and celluloid, it is not so elastic nor flexible. Lack of flexibility is the most serious drawback of bakelite. As an insulator, and for any purposes where it has to resist heat, friction, dampness, steam, or chemicals it is far superior to hard rubber, casein, celluloid, shellac, and in fact all plastics. In price also it can splendidly compete with all these.

Instead of pouring liquid A into a glass tube or mold I may simply dip an object into it or coat it by means of a brush. If I take a piece of wood, and afterward put it into a bakelizer for an hour or so, I am able to provide it rapidly with a hard, brilliant coat of bakelite, superior to any varnish and even better than the most expensive Japanese lacquer. A piece of wood thus treated can be boiled in water for hours without impairing its gloss in the slightest way. I can dip it in alcohol or other solvents, or in chemical solutions and yet not mar the beautiful brilliant finish of its surface. But I can do better, I may prepare an A, much more liquid than this one, and which has great penetrating power, and I may soak cheap, porous soft wood in it, until the fibers have absorbed as much liquid as possible, then transfer the impregnated wood to the bakelizer and let the synthesis take place in and around the fibers of the wood. The result is a very hard wood, as hard as mahogany or ebony, of which the tensile and more specially the crushing strength has been considerably increased and which can stand dilute acids or water or steam; henceforth it is proof against dry rot. I might go further and spend a full evening on this subject alone and tell you how we are now bringing about some unexpected possibilities in the manufacture of furniture and the woodworking industry in general. But I intend to devote a special evening to this subject and show you then how with cheap soft wood we are able to accomplish results which never have been obtained even with the most expensive hard wood.

In the same way I have succeeded in impregnating cheap ordinary cardboard or pulp board and changing it into a hard resisting polished material that can be carved, turned, and brought into many shapes. I might take up much more of your time by simply enumerating to you the applications of this impregnation method, with wood, paper, pulp, asbestos, and other fibrous and cellular materials; how it can be applied for fastening the bristles of shaving brushes, paint brushes, tooth brushes, how it can be used to coat metallic surfaces with a hard resisting protecting material; how it may ultimately supplant tin in canning processes; but I have no doubt that your imagination will easily supply you a list of possible technical uses even if I defer this subject.

As to bakelite itself, you will readily understand that it makes a substance far superior to amber for pipe stems and similar articles. It is not so flexible as celluloid, but it is more durable, stands heat, does not smell, does not catch fire, and at the same time is less expensive.

It makes excellent billiard balls of which the elasticity is very close to that of ivory, in short it can be used for similar purposes like knobs, buttons, knife handles, for which plastics are generally used. But its use for such fancy articles has not much appealed to my efforts as long as there are so many more important applications for engineering purposes.

Bakelite also acts as an excellent binder for all inert filling materials. This makes, that it can be compounded with sawdust, wood pulp, asbestos, coloring materials, in fact with almost anything the use of which is warranted for special purposes. I cannot better illustrate this than by telling you that here you have before you a grindstone made of bakelite and on the other hand a self-lubricating bearing which has been run dry for nine hours at 1,800 revolutions per minute without objectionable heating and without injuring the quickly revolving shaft.

If I mix bakelite with fine sand or slate dust I can make a paste of it which can be applied like a dough to the inside of metallic pipes or containers, or pumps, and after bakelizing, this gives an acid-proof lining very useful in chemical engineering.

Valve seats, which are unaffected by steam, steam-packing that resists steam and chemicals, have been produced in a similar way.

Phonograph records have been made with it, and the fact that bakelite is harder than rubber, shellac, or kindred substances indicates advantageous possibilities in that direction.

For the electrical industry, bakelite has already begun to do some useful work. There, too, its possible applications are numerous. Armatures or fields of dynamos and motors, instead of being varnished with ordinary resinous varnishes, can simply be impregnated with A, then put into a bakelizer and everything transformed into a solid infusible insulating mass; ultimately this may enable us to increase the overload in motors and dynamos by eliminating the possibility of the melting or softening of such insulating varnishes as have been used until now. But the subject of dynamos and motor construction is only at its very modest beginnings and I prefer to mention to you what has been already achieved in the line of molded insulators of which you will find here several very interesting samples.

This brings me to the subject of molding bakelite.

For all plastics like rubber, celluloid, resins, etc., the molding problem is a very important one. Several substances which otherwise might be very valuable are useless now because they cannot economically be molded. The great success of celluloid has mainly been due to the fact that it can easily be molded. Nitrated cellulose alone, is far superior in chemical qualities to celluloid, but until Hyatt's discovery, it could only be given a shape by an evaporation process and its applications were very limited. The addition of camphor and a small amount of solvent to cellulose nitrate was a master-stroke, because it allowed quick and economic molding.

In the same way white sand or silica would be an ideal substance for a good many purposes, could it be easily compressed or molded into shape and into a homogeneous mass. But it cannot; and therefore remains worthless. And that is the main difference between a plastic and a non-plastic. It so happens that bakelite in C condition does not mold; it does not weld together under pressure even if heated; only with much effort is it possible to shape some kind of an object out of it, but some way or another the particles do not stick well together; in other terms, it is not a true plastic. Therefore the molding problem has to be solved in the anterior stages of the process. We have seen how Smith, Luft, and Story tried to solve a similar problem by the admixture of solvents and subsequent evaporation, but we know now that these very solvents imply most serious drawbacks.

I have already shown you how I am able to mold and harden quickly by pouring liquid A into a mold and heating it in a bakelizer. But even that method is much too slow for most purposes. Furthermore, molds cost money; any rubber or celluloid manufacturer will tell you that the item of molds represents a big portion of the cost of his plant. If an order for 10,000 pieces has to be delivered and it takes an hour for molding, it will require between three and four years to fill this order with one mold and if the mold

* Paper read before the New York Section of the American Chemical Society on February 5th, 1909.

costs $100 it will require $5,000 for molds alone if the order has to be finished within 20 days. For that very reason I have devised my molding methods so as to use the molds only during the very minimum of time. I have succeeded in doing so in several ways. One of the simplest ways is the following:

As stated before, the use of bases permits me to make a variety of A that is solid although still fusible. The latter is as brittle as ordinary rosin and can be pulverized and mixed with suitable filling materials. A mixture of the kind is introduced in a mold and put in the hydraulic press, the mold being heated at temperatures preferably about or above 160 to 200 deg. C. The A melts and mixes with the filler, impregnating everything; at the same time it is rapidly transformed into B. But I have told you that B does not melt, so the molded object can be expelled out of the mold after a very short time and the mold can again be refilled. All the molded articles are now in B condition; relatively brittle but infusible. At the end of the day's work or at any other convenient time all the molded articles are put in the bakelizer and this of course without the use of any molds; in this way they are finally transformed in "C" bakelite of maximum strength and hardness and resisting power.

The process can still be further simplified. Instead of using A, we can use B and mold it in the hot press where it welds and shapes itself. After a very short time, the B begins to transform into C and can now be expelled from the mold. If the transformation in C is not complete, a short after-treatment in the bakelizer will finish everything. I have succeeded thus in reducing the molding to less than two minutes for small objects.

The valuable properties of B may be used in many other ways; for instance, A may be poured into a large container and be heated slowly at 70 deg. C. until it sets to a rubber-like mass and shows that it is transformed into B. This block of B if warm has very much the consistency of printers' roller composition, but is brittle when cold. The warm, flexible mass can now be removed from its container or divided, cut, or sawed to any desired shape and the so-shaped articles can be simply placed in a bakelizer; no melting or deformation can occur, so we need no mold while maximum heat is applied to bring everything in condition C.

I could multiply these examples by numerous other modifications of my process but I believe that what I have said will be enough to convince you of its many uses; we are studying now applications of bakelite in more than forty different industries on some of which I shall report on some future occasion.

The chemical constitution of bakelite and the nature of the reactions which occur in the bakelite process are problems which I have endeavored to solve. This subject is not by any means an easy one. Indeed, we have to deal here with a product that cannot be purified by crystallization or other ordinary methods, which is insoluble, does not melt or volatalize; in other terms, it is not a product which is amenable to our usual methods of molecular weight determination. Its chemical inertness makes it unfit for studying possible chemical transformations and unless my friends, the physico-chemists, will come to my aid, discover some way for establishing some optical properties or other physical constants, we are very much at a loss to establish the molecular size of my product.

But I have been so fortunate as to be able to obtain some insight into its chemical constitution by a rather round-about way; indeed, I have succeeded in making bakelite by indirect synthesis.

As stated previously, oxybenzylalcohol if heated at 150 deg. C., or in presence of acids, gives various partial anhydrides, called saliretin, which may resinify further if heated at higher temperatures. Saliretin products are more or less soluble in alcohol and acetone and in NaOH solution, from which they may be reprecipitated by means of NaCl.

We have already seen that DeLaire in heating phenol alcohols in vacuum obtains soluble resins. But I have heated saligenin in sealed tubes under pressure at 180 deg. C. for 8 hours, with and without the addition of small amounts of ammonia. In both cases I obtain a substance which is hard when cold, but which softens when heated, but does not melt. It swells in acetone and in NaOH and dissolves partially. This substance is not my intermediate condensation product B, as no amount of heat can transform it in C.

If, however, I heat oxybenzylalcohol in presence of enough CH_2O or its polymers in a sealed tube at 180 deg. C. for 8 hours, I obtain a substance entirely similar to bakelite in properties and in chemical composition.

By varying the proportions and repeating the experiment a great number of times I succeeded in establishing that, unless I use at least 1 molecule of CH_2O for 6 molecules of oxybenzylalcohol I do not obtain bakelite but a product containing saliretin compounds.

The same result occurs by heating 6 molecules of phenol and 7 molecules of CH_2O in presence of a small amount of a base.

If I use somewhat less formaldehyde or if for some reason or another all the formaldehyde does not enter into reaction, I obtain a substance which may still be attacked by acetone, probably because it contains uncombined phenol or saliretins after the reaction is over.

But I have found that all these substances, whether they are obtained by heating 6 molecules of phenol alcohol with at least one molecule of CH_2O, or whether they are obtained by the action of phenol on formaldehyde under heat and pressure in presence of small amount of bases, can be purified and brought to about constant composition as follows:

The substance is pulverized, washed with 5 per cent KOH solution, with dilute HCl, with alcohol, with acetone and finally dried to constant weight *in vacuo*.

The powder so obtained still contains traces of potassium, which I did not succeed in eliminating. The amount of same is very small, about 0.09 per cent of ash, but it seems to cling tenaciously to the product and makes it somewhat hygroscopic making weighing for analytical purposes very difficult, and accounts for some variations in the results.

The organic combustion of all these products gave the following results:

1 mole CH_2O ... 6 mole saligenin ...	C = 77.48	77.88
	H = 5.96	5.97
	O = 16.56	16.15
1 mole CH_2O ... 4 mole saligenin ...	C = 76.47	76.35
	H = 5.44	5.40
	O = 18.09	18.25
13 mole CH_2O ... 12 mole saligenin ...	C = 76.59	76.57
	H = 5.97	5.97
	O = 17.44	17.46
1 mole phenol ... 1 mole CH_2O ... and 1 per cent NH_3 ...	C = 77.48	76.61
	H = 5.60	5.80
	O = 16.92	17.59
10 cc. phenol ... 10 cc. 40 per cent formaldehyde. and ½ per cent NH_3...	C = 77.92	75.62
	H = 5.71	5.78
	O = 16.37	18.60[31]

If we take into consideration the great difficulties encountered in purifying methods, these results seem to indicate that we have to deal here with a definite organic substance of constant composition, which according to its methods of preparation may exist with impurities mixed in various proportions. These impurities are probably free phenol, or free CH_2O or saliretin products.

From the indirect synthesis of bakelite by means of oxybenzylalcohol and CH_2O, I am led to consider bakelite in its simplest form as a polymerized oxybenzyl—methylen-glycol—anhydride which, in case of ordinary phenol, might be represented by the following formula:

$$n(C_{43}H_{38}O_7).$$

The reaction being represented by:

$$n\ (6C_7H_8O_2 + CH_2(OH)_2) = n\ (C_{43}H_{38}O_7) + n\ (7H_2O.)$$

This formula corresponds acceptably to the analytical results if we take in consideration the difficulties of purification.

	C.	H.	O.
Calculated ...	= 77.44	5.75	16.81
Found (average) ..	= 77.68	5.96	16.36

(with product of 6 mole saligenin + 1 mole CH_2O).

I consider bakelite C as a direct polymer of another anhydride which is represented by my intermediate condensation product or bakelite B. Bakelite B is a more complete anhydride than bakelite A. As to bakelite A, I am unable to arrive at a constant composition, for the reason that it easily gives off water, changing gradually its composition until heating converts it slowly into B, after passing through various mixtures of A and B.

My supposition has a strong appearance of probability by the following experiment:

If I put a mixture of phenol and formaldehyde in proper proportions and with some small amount of a base in a sealed glass tube and heat just long enough to produce A the formerly homogeneous liquid mixture separates into two layers. The initial condensation product A forms a lower stratum, and a supernatant layer of liquid indicates the elimination of water. The same thing occurs if anhydrous phenol is heated with paraform in presence of a small amount of base.

If this A, first properly freed from any physically retained water, be introduced into another sealed tube and heated further, I may succeed, with some precaution as to the duration of heating, in stopping just in time so as to transform everything into B, the intermediate condensation product. I then see that a new amount of water is set free which will assemble on top, giving evidence of further dehydration. At the same time we notice that the mass B has not contracted in volume to any important extent.

If now this B, properly freed from water, be heated in another sealed tube, it will be transformed finally into C. But this time we see no further elimination of water. On the other hand there is a decided contraction of volume.

[31] Beginning oxidation during drying.

This contraction of volume, together with the remarkable increase in physical and chemical inertness, points toward the probability that C is simply the polymer of B.

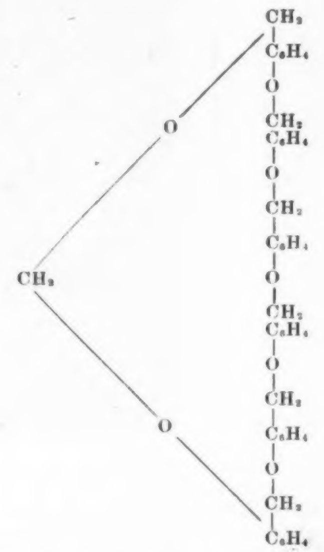
I am fully supported in this belief by the fact that analysis has shown me that B and C contain the same percentage of carbon, hydrogen, and oxygen.

If we accept these premises then the theory of the bakelite process is easy to explain:

Stage A.—Formation of a partial anhydride of a phenol alcohol and methylen glycol containing hydroxyl groups, which can fix NaOH.

Stage B.—Formation of a higher anhydride by further elimination of water. This higher anhydride seems no longer to possess hydroxyl groups, but by addition of NaOH may still form alkaline compounds. This induces me to believe that in some way or another we shall succeed in obtaining alkali compounds of the kind which on being treated with dilute acids will regenerate A.

Until we have anything better, I shall propose the formula:



Stage C.—Polymerization of the B product resulting in greater chemical inertness and disappearance of active corners of the molecule.

With homologs of phenol we obtain the direct homologs of these anhydrides; for instance, with orthocresol we get the polymer of ortho-methyl-oxybenzyl-methylen-glycol-anhydride.

It may be of interest to remind you that many years ago, Oscar Low[32] called our attention to the great importance of formaldehyde as a starting point of synthesis in plant life. By the photo-chemical action of sunlight on CO_2 in presence of water in chlorophyl, oxygen is liberated and produces CH_2O. This is the beginning of a process of further synthesis building up more complicated bodies.

I shall also call your attention to the fact that the willow tree produces in its cells, salicin, which is the glucoside of saligenin; this same saligenin or oxybenzyl alcohol in presence of more CH_2O has given me bakelite.

On the other hand Bertrand,[33] and Tschirch and Stevan[34] and more recently R. Majima and S. Cho[35] have called our attention to the phenolic nature of resinous substances, specially Japanese lacquer. The latter substance has some analogy with bakelite and exudes from the *Rhus vernicifera Dc.* which is a plant that is somewhat related to our American "poison ivy."

So after all, the synthesis accomplished in my laboratory seems to have a decided similarity to some intricate biological processes that take place in the cells of certain plants.

In order not to increase too much the length of this paper, I have merely given you the brief outlines of years of arduous but fascinating work, in which I have been ably helped by Mr. Nathaniel Thurlow and more recently also by Dr. A. H. Gotthelf, who attended to my analytical work.

The opened field is so vast that I look forward with the pleasure of anticipation to many more years of work in the same direction.

I have preferred to forego secrecy about my work, relying solely on the strength of my patents as a protection.

It will be a great pleasure to me if in doing so, I may stimulate further interest in this subject among my fellow chemists and if this may lead them to succeed in perfecting my methods or increase still further the number of useful applications of this interesting compound.

[32] Ber., 22, 475 and 23, 398 and 480.

[33] Ann. Chim. Phys. [6]. 12, 115 (1896); Bull. Soc. Chim. [3], 11, 614 and 717 (1894).

[34] Tschirch und Stevan, Arch. d Pharm., 243, 504 (1905).

[35] Ber., 15, November, 1907, page 4390.

THE MACHINES THAT MAKE CORDAGE.*

HOW VARIOUS FIBERS ARE MECHANICALLY FORMED INTO ROPE.

The expression "done by a twist of the wrist" would very fairly describe the method of manufacturing rope, even a very few years ago. At the present time there are still a few relics of the once familiar, long, low buildings, known as the ropewalk, but these are growing fewer and fewer and practically all of the rope commercially manufactured in this country is now made by automatic machinery.

What is known as hemp rope is made principally of two vegetable fibers, manila, which, as is well known, is the most important product of our Philippine possessions, and sisal, which comes from Yucatan in Mexico., The manila fiber really makes very much the better rope, and sisal rope is used only where strength and durability are not the leading requirements.

THE MANILA.

Manila plants are not greatly different from banana plants and are of the same botanical family. The leaves grow up from the ground in a close bunch, giving the appearance of an ordinary tree trunk; but at a height of about 12 feet from the ground, these branch out into long, somewhat palm-like leaves as is often seen in characteristic photograph of tropical vegetation. The manila fiber comes from the portion of the leaf which grows along the trunk of the tree.

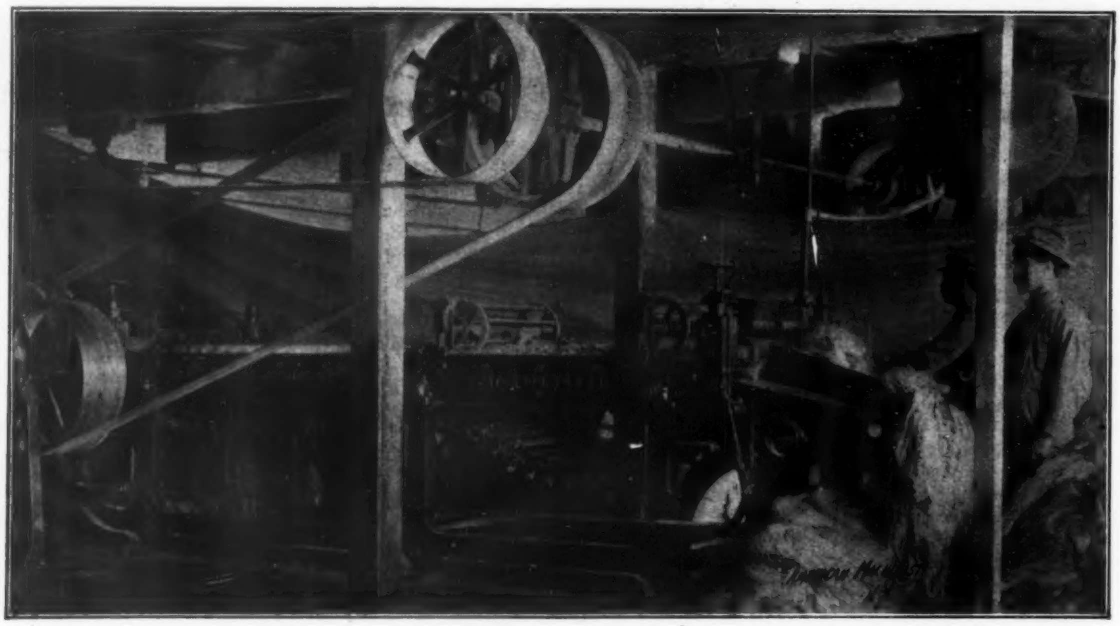


FIG. 1.—THE BREAKER OR COMBING MACHINE, SHOWING OIL SPRAYER.

Not far from the ground the leaves are cut off and separated from the other stalks forming the trunk, and after the upper portions of the leaves have been removed, the stalks are cut longitudinally into strips. Next the pulp is removed from the fiber by drawing these strips between a dull knife blade and a hard wood block. This operation of drawing the fiber to remove the pulp is said to be very laborious, but up to the present time, no satisfactory machine has been developed to do this work mechanically. The native grasps the fiber, which he draws through the scraping device, and coiling it around his arm is able to hold it firmly and draw it through, a short length at a time, continuing to wrap the drawn fiber around his arm and to take a new grip as the fiber comes through.

Several attempts have been made to design machinery to do this, but any mechanical gripping device greatly injures the fiber, and there does not seem to be any method of holding it as good as that of the native who wraps it around his arm and grips it with his hand. The fiber is next dried in the sun, and it is then sorted into different grades and pressed into bales for shipping to this and other countries, where it is made into rope, the better grades generally coming to the United States.

THE SISAL.

Sisal fiber comes from Mexico, as said. The sisal plant is very similar to the ordinary century plant in appearance, but it is only certain parts of Mexico where fiber suitable for the making of rope from this plant will grow. The growing of the sisal is a large industry, and there are many broad plantations in Mexico devoted to its cultivation. The leaves or

* By courtesy of the American Machinist.

FIG. 2.—A SISAL PLANTATION IN MEXICO.

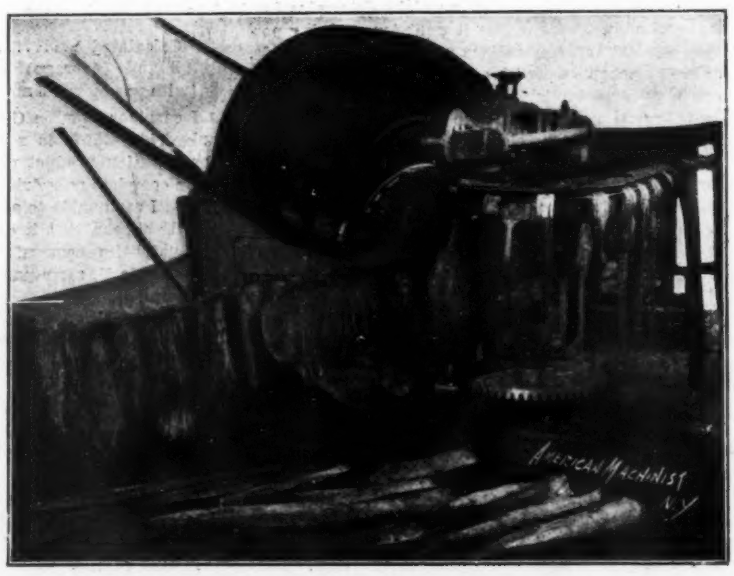


FIG. 3.—SISAL MACHINE REMOVING PULP FROM THE FIBERS.

FIG. 4.—FEEDING THE FIBERS INTO THE SPREADER.

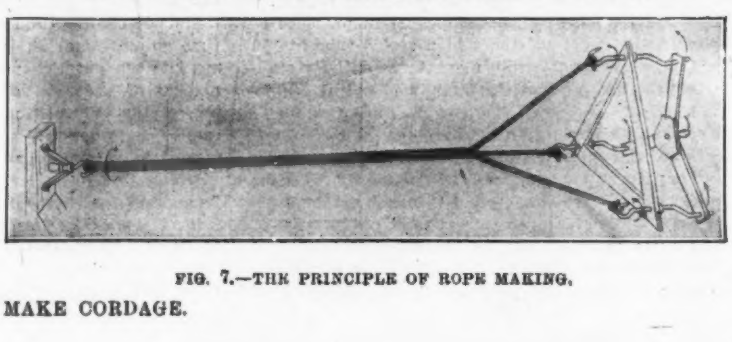


FIG. 7.—THE PRINCIPLE OF ROPE MAKING.

THE MACHINES THAT MAKE CORDAGE.

spines when cut off are about four feet long and have the shape of sharpened wooden stakes.

These leaves, which are known as pencas, are run through a machine which removes the pulp, leaving the fiber. The action of this machine is simply that of a series of scraping knives on the periphery of a revolving wheel. The knives are dull-edged and scrape along the length of the leaves against a curved metal plate following the periphery of the wheel. This quite effectively removes the pulp, and the long fibers are carried out by a chain belt and then after being sun dried are packed into bales.

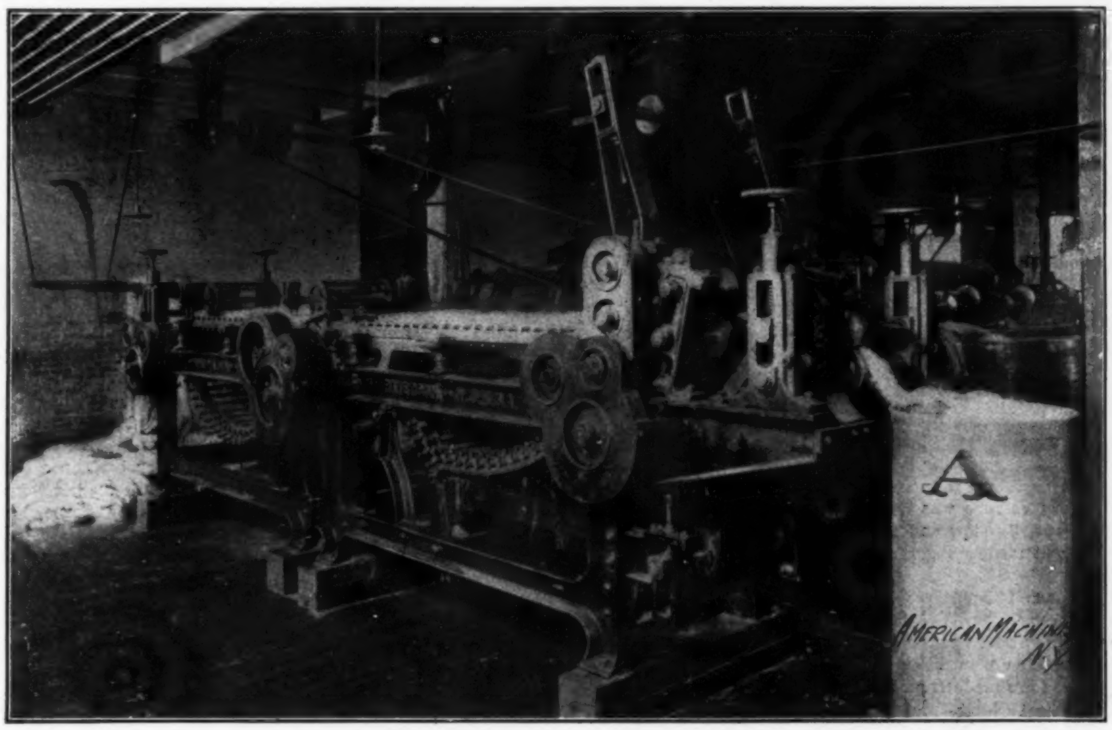


FIG. 5.—SEPARATING AND FINISHING MACHINE.

HAND METHODS.

It is probable that the old method of making rope by hand did not change very much from the times when the Egyptians used rope to lift the stones to build the pyramids. There are many records in ancient history where ropes were used, so that rope itself is anything but a modern invention. It is only the adaptation of automatic machinery to the production of rope which is at all modern.

In the old days the ropemaker wound a bunch of hemp around his body, and fastening part of it to a hook in the wall he walked slowly backward while he drew out from the bunch around his body small portions of hemp which he added to that fastened to the hook and twisted it round and round with his fingers, the hook holding the hemp being turned by another person. As he added more material he continued to twist and to back, and in that way eventually produced cord or yarn of the hempen fiber. This yarn was afterward twisted into strands and then into ropes having three or four strands, and as times progressed, more and more mechanical devices, though of crude form, were produced to assist the hand laborer in the work of laying and twisting the rope so as to produce a better product and at the same time do it more quickly.

The underlying principle in rope making, which is fairly well known, is that each individual strand making up the rope has a certain twist given to it within itself, and the combined twist of these strands reacting against each other frictionally causes the whole rope to stay in a naturally twisted condition. The illustrations accompanying this article show several of the machines which are used in the manufacture of rope.

FIG. 6.—ANOTHER FORM OF FINISHER. THE FIBERS READY FOR SPINNING.

THE MACHINES THAT MAKE CORDAGE.

"A TWISTER."

Fig. 7 is a diagram of a very crude rope-making machine, and perhaps it should be said in justice to modern rope manufacturers that no such machine as this is in use in any of the factories. However, it very simply illustrates the principle upon which rope is laid or twisted into shape. In this illustration it will be seen that a triangular frame has projecting through each of its three corners a hook, which at the back of the frame is bent into the shape of a crank. Each of these cranks projects through one arm of a three-armed frame, and in the center of this three-armed frame there is a handle by means of which this three-armed frame may be caused to describe a circle so that each one of the hooks and cranks may be made to revolve on its own axis, all revolving at the same speed. It must, of course, be understood that the triangular frame which supports the axes of the three hooks does not itself revolve, but that each hook revolves only on its own center by the action of the cranks and the three-armed frame back of the triangular frame.

As shown, each of the three hooks carries one strand of a three-strand rope, this rope being fastened to a swivel hook at the other end of the illustration. This swivel hook is entirely free to turn on its own axis as the rope twists. Starting out with three strands passing from the three hooks directly to the swivel hook at the other end, it will be understood that as the three-armed frame with its handle is moved, causing the three hooks to revolve, each one of three strands is twisted on its own axis. It will be found that as the twisting continues the three strands have a very strong tendency to wind about each other, and at the same time the far ends of these strands will begin to

turn in the same direction as the rotation of each one of the hooks. These various rotations and motions are indicated by the arrows in the illustration.

As the motion of twisting the hooks continues, the twisting of the strands and their tendency to wind about each other and to rotate the swivel hook at the far end produces a genuine rope, which, if cut off at any point in its length, will remain in its twisted condition just like any good first-class rope. As a matter of fact, in order to get the correct tension on all parts of the rope thus formed, the swivel hook at the far end of this crude device would be provided with a wheel by which another operator would assist the rope in twisting upon itself, because the friction of the parts would have a tendency to prevent the rope from twisting up as tightly or as evenly as it naturally would. This, then, is the principle underlying the making of rope, and it is the individual twist given to each strand which makes the rope have its tendency to remain in a twisted condition.

As may be surmised, the twisting up of the strands and the formation of the rope, illustrated in Fig. 7, will cause the rope to grow shorter and shorter, and in the old-fashioned ropewalks, where a modification of this device was used not so very long ago, a track was provided by which the twisting mechanism could travel along the rope walk as the rope became more and more twisted, and consequently shorter and shorter. Suitable means were provided for keeping a uniform tension on the rope as it was formed, and in this way a very good quality of rope was made, although the process was necessarily slow and the output probably not so uniform as modern machine-made rope.

Before the three strands are twisted into the finished rope it is of course necessary to make the strands, and each of these individual strands is made up by twisting together a number of smaller strands known as yarns. These yarns are made from the manila and sisal in spinning machines which draw out and twist the fibers into the shape of a yarn which is wound on a bobbin by the machine. Before the fibers coming from the Philippines and from Mexico can be twisted into yarn, there is some little preparation necessary.

COMBING OUT THE FIBER.

Manila fiber has first to pass through a softening machine. This machine is simply a series of from six to ten heavy fluted rollers, and as the manila hemp passes through these rollers, oil of a certain kind is sprinkled over the material to soften it. After this an attendant grabs a bunch of the fibers and gives them a rough combing out by throwing the end of the bunch over a revolving wheel carrying a large number of steel points in its periphery, the bunch of fibers being grasped in the middle by the operator.

After thus being roughly straightened out, the fiber is fed to what is known as the breaker. This machine consists mainly of two endless traveling chains placed in series with each other. In these chains a very large number of steel pins are fastened, giving an appearance not greatly different from an immense curry comb. The second chain in the series travels from six to ten times as fast as the first chain, and as the manila fiber is fed first to the slow chain and is carried forward by its motion, the material is delivered to the second chain traveling at the higher speed. These two different speeds of the two chains in series draw out the fibers, tending to make them straighter and straighter, and of course at the high speed tending to diminish the number of fibers in a given cross section, drawing them out into a long stream known as a sliver.

Slivers from several machines are brought together and passed into still another machine, and so on, the machines becoming of lighter and lighter construction, and drawing the fiber out straighter and straighter and longer and longer. Manila hemp will be worked on from four to six of these double-chain breakers and similar but lighter machines called spreaders, and sisal will require from five to eight workings. After this number of combings on the double-chain machines, the fibers pass to what are known as the drawing frames. These drawing frames are almost identical with the breakers and spreaders except that they are much lighter in construction and also that they are provided with only a single chain instead of two in series traveling at different speeds. The drawing frames are, however, provided with fluted rollers at the end, and these rollers travel at a speed of from four to six times that of the chain, thus further drawing and combing out the fibers and preparing them for spinning into the yarn.

From the drawing frame the fibers progress to the finishers, which differ from the drawing frames mainly in the fact that instead of the fluted rollers at the end there are two revolving leather belts, as shown in Fig. 5. These belts travel on rollers so situated relative to each other that the belts press against each other in a loop during a part of their travel, and the sliver delivered by the chain belt just back of the leather belt is passed between the two leather belts just at the point where this loop commences. The sliver is then carried in and up and over several rollers, the action of the rollers and belts being to press the fibers closely together. After making this circuitous course between the two leather belts, the sliver is delivered to two iron rollers which further compact the material so that it passes out in a narrow continuous stream. The slivers are delivered into metallic cans, where the fibers naturally coil round and round in neat figures without becoming tangled among themselves.

There are also other machines as shown in Fig. 6 which combine the traveling chain comb and heavily-weighted rollers which finish the sliver ready for the spinning jennies.

(To be continued.)

THE DEVELOPMENT OF THE GAS ENGINE.

A CRITIQUE OF RECENT DESIGNS.

It has been said that difficulties only occur to the engineer to be overcome, a remark which, though savoring somewhat of hyperbole, may be generally accepted, with the reservation that the process is often slow and tedious. This is especially so when principles are not completely understood, and progress has become to a great extent a matter of trial and error, or, if you will, rule of thumb. It is always interesting, and sometimes profitable, to trace the development and endeavor to forecast the future of some particular branch of engineering by a process analogous to plotting and extending a curve. In the case of the gas engine the development has been remarkable, though probably not so rapid as seemed at one time probable. What have been and what are the obstacles to progress? Before answering this question it is necessary to remark that for small powers, the upper limit of which it is not easy to define, but which may be taken as between 300 and 500 horse-power, the gas engine as a simple, reliable, and economical prime mover holds the field. This is a general statement, and like all such, must be qualified, the exceptions being those special cases, such as marine propulsion, where the successful application depends much more on perfection of detail than on any questions of principle. In these cases sufficient pioneer work has not yet been done, though there can be little doubt of the ultimate result.

Leaving the small gas engine and considering the larger powers, we find that, as in all other engineering problems, it has two aspects, the technical and the financial or commercial, and these cannot be entirely separated, for it is obvious that a first condition to be realized before an industry can develop is that the article manufactured can be sold at a profit, while on the other hand it is also necessary that after being sold it shall, as the result of knowledge and forethought in design and manufacture, continue to give satisfaction in the hands of the user. It is necessary to touch briefly on the financial aspect of the question, because some of the hindrance has been due to causes of this nature. It is known that some makers have held back from making the larger size gas engines, not because they feared the engineering difficulties, but because they were not convinced that there was any money in it. It would seem at first strange that there should be one law for the small gas engine and another for the large. Every species of manufactured article has its own particular law of cost which follows directly from the engineering conditions or requirements. In a steam installation, for example, the engineering conditions say that for a given power the cylinders, shafts, etc., must be of a certain size, the boiler must have a certain amount of heating surface, and so on, all of which determine the amount of material to be employed and the amount of labor to be spent upon it, and hence are determining factors in the ultimate cost. As we proceed from one size to another, we find, as we should expect, that the total cost varies in no simple manner, being made up as it is of a large number of separate items, each varying in its own particular way. The cost of different sizes can, however, as a rule, be plotted on a curve, and such curves are very useful and instructive when applied to the manufacture of a number of articles of the same species, but of different size, and they show graphically what we have called the law of cost. If plotted with horse-power as abscissæ and cost per horse-power as ordinates, the law for most prime movers shows the general characteristic that the cost per horse-power diminishes as the horse-power rises. This characteristic will be most marked where the engines, motors, or whatever the prime mover may be, are all of identical type, consisting of the same number of parts, differing only in dimensions, where, in short, the small may be considered as a model of the large. In the case of steam machinery, for example, whether reciprocating or turbine, we can pass from a small size to a large without any change in the general features of the design; but this is not the case with the gas engine, where beyond a certain diameter of cylinder the engineering requirements which follow from the high temperatures and thickness of metal demand special consideration and a radical change in design. Up to a certain power the single-acting cylinder with unjacketed piston and ordinary mushroom valves quite meets the case, but above this size the exhaust valve and piston must be water-jacketed. At this point we should find a discontinuity in the curve of cost which will rise suddenly due to these additions. The increase, moreover, will be greater than would at first sight appear, for the addition of the water jacket to the piston involves heavier reciprocating weight, a slower speed of revolution, and therefore a larger engine. Proceeding upward in power, we arrive at a point where, owing to increase of diameter of the cylinder, it becomes desirable either to make the engine double-acting or subdivide the power in two cylinders. Either alternative means additional cost, for the double-acting cylinder means a water-cooled piston-rod, external guides and other working parts again adding to the reciprocating weights with a further reduction of speed of revolution. The latter alternative involves duplication of parts with increased cost of machining, fitting, and erecting. In the larger sizes also it is generally deemed advisable to fit more elaborate and costly mechanism for working the valves. Other factors have contributed to make the large gas engine a rather costly thing to produce, and this disadvantage has weighed against it except in cases where the fuel is to be had for nothing, as in the waste gases for blast furnaces, though even here some engineers favor the burning of the gases under a boiler and using the steam in a turbine. The advance made in steam turbine construction and economy of recent years has undoubtedly to some extent hindered the growth of the large gas engine. Turning to the purely engineering side of the question, the problem of extending the gas engine to larger units resolves itself largely into the consideration of the stresses set up by the high temperature in the cylinder and in the avoidance of pre-ignition. The large gas engines which have been run successfully in this country and on the Continent using blast furnace and similar waste gases are a class to themselves, and so far have not been greatly employed with gases of higher calorific value. It is the engines using mainly producer gas to which we now refer. No difficulty is to be feared in the mechanical problems to be solved, it is only the thermal conditions which cause anxiety, and though experience is daily accumulating, it is mostly a record of effects the causes of which are as yet imperfectly understood.

In a recent paper Prof. Hopkinson showed what the temperatures were in an uncooled piston, and calculated the magnitude of the stresses set up. It is common knowledge that the troubles due to unequal expansion are more often met in the water-jacketed ends, and these are frequently of such complex construction that even if the difference of temperature on the two sides of the metal were accurately known, it would be quite impossible to calculate the stress. It is known, however, that the stresses increase rapidly as the size of cylinder and thickness of metal is increased, and the general direction in which this difficulty is being met is in the avoidance of extraneous causes which would tend to facilitate fracture, and in the use of stronger material, such as cast steel in lieu of cast iron. The most common of the extraneous causes is "casting stress," and it is now the almost universal practice to simplify the cylinder-end casting as much as possible, and avoid tying the parts to one another by rigid connections. Probably sufficient attention has not yet been directed to the use of cast steel. The stronger material enables the thickness of the walls to be reduced for a given diameter of cylinder; the temperature difference is reduced, and the stresses due to unequal expansion reduced also. It will be noted that in the inner surface of the wall of a cylin-

der end the stresses due to the pressure in the cylinder, and the expansion due to temperature, are both compressive, and the real stress is their sum. Making the wall thinner will increase the stress due to the pressure, but diminish the stress due to temperature, because the temperature difference has been reduced. This point is sometimes lost sight of, and accounts for the fact that an increase of thickness has often failed to cure fractures of cylinder ends. There appears to be a tendency at the present time toward the engine with several cylinders, so as to keep the unit below the line where expansion troubles commence, the multiplication of parts being accepted as the lesser evil. Moreover, the engine with several cylinders has advantages in some cases where even turning moment and higher speeds of revolution are desired. This movement appears a good policy pending further experience with the larger-sized cylinders.—The Engineer.

COPPER-CLAD STEEL.*

A METALLURGICAL NOVELTY.

BY WIRT TASSIN.

FOR many years past attempts have been made to cover steel with a copper coat which could be of any desired thickness, and to so firmly weld the two metals that the combined product could be submitted to any of the usual methods for working metals without destroying the integrity of this weld.

The many methods tried in the past have been more or less successful failures, either from a metallurgical or a commercial standpoint, and it is only recently that a process has been developed for the successful welding of copper to steel in such a manner that it will stand the many methods used for working metals, and be at the same time a commercial metallurgical product.

The weld between the copper and the steel is perfect within the limitations of a metallurgical process. The copper can be separated from the steel only by melting it off. The weld will resist sudden temperature changes such as heating the combined metals red hot and then quenching them in ice water. It will resist both stress and shock.

DETAILS OF THE PROCESS.

The process by which this result is obtained may be described as follows: Steel of any desired composition and shape, which, for the purpose of this description, will be regarded as being a mild basic open-hearth steel, rolled into rounds and cut into 26-inch billets to make wire rods, is sandblasted and pickled to remove the scale. The billet, which has previously been drilled and tapped at each end, is hung by means of a rod and bushing screwed into one end, in a preheater, and is brought to a red heat. When the desired temperature has been reached, the billet is then drawn into a tube (also previously heated) by means of a rod which is screwed into the top of the bushing. This rod slides up and down in the center hole of a three-jawed chuck, which holds the tube and centers the billet in it. A steel flange is then screwed on the bottom of the billet, thus forming with the tube a mold in which the billet is the core.

The mold and billet are now carried to a pot of specially-prepared copper which is in a super-molten condition. The billet with its attached flange is now lowered out of the tube and into this copper, and kept there for a length of time sufficient to wet the surface of the steel and to form an alloy film. The billet is then drawn from the copper up into the tube, and the billet and its mold are carried to a second pot containing commercially-pure copper, in which the final coat of copper is applied. The mold with its billet as a core is lowered into this pot, and the molten copper rushes in through two openings in the top of the tube until the mold is filled. The mold is then withdrawn from the second crucible, and when the copper has frozen, the chuck, rod, and flange are unscrewed. The tube and its contents are next placed in a ram, and the copper-clad steel billet is pushed out of its mold. The billet is now given a washing heat and is then rolled to the desired size.

The rolling is in general similar to that of steel or copper, and it is interesting to note that in spite of the great differences between the physical properties of copper and steel, the two metals when so welded have, under proper conditions, practically the same rate of flow. The proportional areas of the copper and the steel remain practically a constant from the larger to the smaller sizes.

UNUSUAL TENSILE STRENGTH.

The tensile strength of the copper-clad steel is also remarkable. Regarding the metal as having 40 per cent of its sectional area made up of copper, its tensile strength after the proper treatment is equal to and may be greater than that of a steel having a composition similar to that of the steel in the copper-clad, but whose sectional area is equal to that of the clad metal. An illustration of this may be seen in the accompanying table of commercial wires, in which due allowance must be made for the difference between hard and soft drawing:

Strength of Various Wires.

Name.	Diameter. in Inches.	Breaking Weight in Lbs.
Galvanized steel	0.162	1,406
B. B.	0.162	1,250
E. B. B.	0.162	1,140
Copper	0.162	1,237
Copper-clad	0.162	1,874

This table is an illustration of the fact that the tensile strength of the copper-clad steel is not the mean of the strength of copper and steel, for the composition of the steel in galvanized wire quoted is practically that of the steel in copper-clad, and making liberal allowance for the difference in the heat treatment of the two, the breaking weight of the copper-clad is equal to if not greater than that of the galvanized, and but six-tenths of it is steel.

The above statement is also true of its elastic limit, which will average 90 per cent of its tensile strength. The elastic limit of copper under the best conditions is 60 per cent of its ultimate strength. That of steel is a variable, but for comparison take it at 90 per cent. Copper-clad steel, four-tenths of whose sectional area is a metal having a relatively low elastic limit, gives a figure directly comparable with that of steel treated under like conditions whose sectional area is equal to that of copper-clad, and whose composition is similar to that of the steel composing its core.

GALVANIC ACTION.

Copper and steel in the presence of moisture form a galvanic couple, and the corrosion of the steel proceeds with great rapidity. The resistance to corrosion of copper-clad steel, so far as the copper coating is concerned, is of course the same as that of copper. But in view of the marked galvanic action set up between copper and steel, it would be assumed that corrosion would quickly occur at the exposed ends, and be a constant factor so long as an electrolyte was present. This supposition is not so, at least in the presence of fresh or salt water. Test samples placed in water, through which a current of air has been allowed to bubble continuously for three months, demonstrated that after a certain period of time, somewhere between fifteen and forty days, corrosion practically ceases, as shown by taking the loss in weight of the tests at varying periods. It is believed that this stopping of corrosion is a result of the following conditions:

After a certain amount of rust has been formed, it appears that a thin film of copper mixed with some copper oxide is plated out or deposited between the iron oxide and the unattacked steel, and that this film will act as a preservative coat as long as it remains intact. If broken, further oxidation is set up and the process simply repeats itself. While it is true that the corrosion on the end of a wire is not a factor in its life, yet the corrosion of the end of a relatively large diameter may become serious. If the above observations hold true on larger sizes (so far it has not been tried on sizes above ⅝ inch), it will have quite a bearing on material suitable for marine work. Tests along this line are now being carried out, and the evidence to date points to a confirmation of the observations made on the smaller sizes.

POSSIBLE USES.

The uses to which copper-clad steel may be put are many. The first and most obvious is a wire to be used for electrical and mechanical purposes. The conductivity requirements for electrical use depend directly upon the amount and kind of copper used in the coat. Thus a copper-clad wire, four-tenths of whose sectional area is copper, will have a conductivity of 40, since both copper and steel wire possess certain disadvantages for electrical work, the one having a low tensile strength and under given conditions a lack of toughness, the other having a low conductivity and being subject to a more or less rapid corrosion.

Copper-clad wire has a strength and toughness equal to that of steel, a conductivity far greater than that of steel, and it will not corrode. For example, in telephone work the life of a line is dependent upon its breaking weight and elastic limit. The breaking weight and elastic limit of a No. 10 copper wire are respectively 530 and 293 pounds, while that of a No. 14 copper-clad is 760 and 320 pounds. The one weighs 166 pounds per mile and the other 61. Comparing copper-clad with galvanized-iron telephone wire, a much smaller size of copper-clad may be used for the same ohmic resistance.

Resistance of Galvanized and Copper-Clad Wire.

Wire.	Diameter. Inch.	Ohms. per Mile.	Weight, Per Mile, Lbs.
E. B. B.	0.134	18.83	250
B. B	0.134	22.04	250
Copper-clad	0.134	7 50	266

Where a high tensile strength and resistance to corrosion is an essential and an increased conductivity is desirable, as for example in power transmission requiring long spans and in catenaries, its value is apparent.

For mechanical purposes, such as bridge work, derrick guys, rigging, springs, rounds of all sizes suitable for anchor bolts, pump rods, etc., where resistance to corrosion combined with a high tensile strength is an essential, copper-clad steel is admirably adapted since steel having any desired physical qualities may be used as the core. For large structural shapes it is questionable whether this material will ever have a commercial use, but for light shapes suitable for skylight and similar work, its value is obvious. It is non-corrodible and possesses the strength of steel. Copper is weak, and galvanized iron corrodes.

To sum up, the material has a greater strength than copper, and under given conditions equal, if not greater, strength than steel. It has a greater conductivity than steel and less than that of copper. Its resistance to corrosion is equal to that of copper and immeasurably greater than that of steel.

* Reprint from Journ. Ind. and Eng. Chem.

PLANS FOR REBUILDING THE QUEBEC BRIDGE.

THE Canadian Minister of Railways held a meeting recently with the three engineers appointed to design the new Quebec bridge, and the three other engineers appointed lately to consult with them in the rebuilding of the great cantilever bridge over the St. Lawrence River, which collapsed August 29th, 1907. As a result of this meeting it was announced that practically all the vital points as to the style of the new structure, etc., had been decided on, and that the preparation of plans would be gone on with at once. Plans for both cantilever and suspension types of bridge will be prepared simultaneously, and bids called for both. The general principles already decided upon will make the bridge a much more substantial structure than the fallen one. It will be 150 feet above high tide, and if the cantilever type is chosen will be of the straight type, without the arch effect of the old structure. It will be 85 feet wide from center to center of trusses, or 24 feet wider than the old bridge. The increased width will give ample room to accommodate the steam and electric railway tracks, roadway, footpaths, etc. The center span will be reduced from 1,800 feet to 1,717 feet. This will be accomplished by the erection of another pier on the Quebec side, 100 feet from the existing deep water pier. In addition to this, the pier on the south side will be enlarged to allow for the greater width and bearing power required. It has also been decided to use a considerable amount of nickel steel in the construction of the new bridge. The Minister of Railways expressed his hope of an early start being made with construction, but it is not known when bids can be asked.

MECHANICAL AIDS TO RAILROAD BUILDING.

MODERN RAILROAD BED CONSTRUCTION AND TRACK GRADING BY MACHINERY.

BY FRANK C. PERKINS.

A most interesting track-grading machine has been developed recently at Duluth, Minn. From the accompanying illustrations it will be noted that the machine is designed to run either on a railway track or on a highway, and to draw up earth from the side of the roadbed to the top of the bed. It is especially designed for use in raising the grade of a railway roadbed upon which a track has already been laid. When utilized for this purpose the apparatus is equipped with means

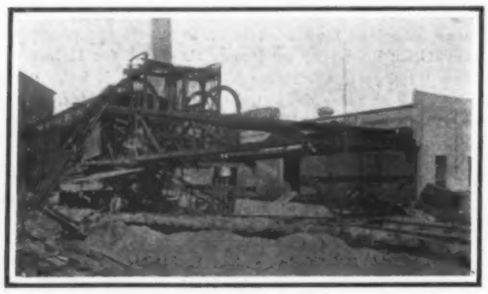


Fig. 1.—TRACK GRADING MACHINE WITH SHOVEL ARMS EXTENDED READY FOR FORCING DIRT UNDER TRACK.

for lifting the track and holding it in suspension while the new earth is being moved into position. It may be stated that the machine can be operated by five men —two on the main car, one on the chair suspended from the carriage on the boom, and two on the ground at opposite sides of the boom. This machine and five men are capable of taking the place of a gang of from 75 to 125 men and their shovels, tampers, and lifting jacks.

One track lift is located at the forward end of the boom, while the other is situated about the center of the boom and works automatically with the carriage. When the track is ballasted out to the center of the boom, the center track lift is replaced and the carriage pushes it forward, after which the end of the boom is coupled on. When the carriage is moved back next to the car, it pulls the center track lift back with it and is released automatically when it is about at the center of the boom. This leaves the center track lift in position, when the car moves forward to make another lift of the depressed portion of the track forward of the car.

There is a distance of 20 feet 8 inches between the shovels. The batteries of shovel arms may be noted in the accompanying illustration, Fig. 1. This view shows the carriage at the extreme end of the boom with one battery of shovel arms out and the other in. The man in the chair underneath the carriage controls the action of these shovels by levers, there being four independent engines on the carriage, two for each

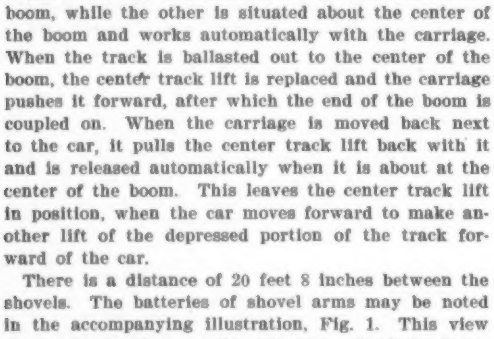


Fig. 2.—TRACK GRADING MACHINE WITH SHOVEL ARMS FORCING DIRT UNDER TIES.

side. The engine on one side runs the shovel arms up and down while the other engine runs the shovel arms in and out.

The carriage at the end of the boom is seen in Fig. 2, with a battery of shovel arms in the position they would assume in case the track were lifted and the dirt were shoved underneath the ties, that being the first move made. The interior of the machine is equipped with the necessary levers, friction for the propelling gear but friction for the gear that runs the carriage back and forth on the boom. A large drum carries the copper hose which furnishes steam for the engine on the carriage. This hose is unreeled as the carriage is moved out to the end of the boom and back as the carriage travels backward toward the car.

The movement of the track into position is noted in Fig. 3, while Fig. 4 shows the movement of the arms in handling the grading material.

The construction of the machine embodies a modified flat car of about 40 feet length, upon which is a pivoted platform or turntable. Upon this and the turntable are mounted the boiler, the transporting engine geared to the trucks, pivoted masts, as well as certain other operating machinery.

One illustration shows a skeleton boom in the shape of a parallelogram extending forwardly about 32 feet from the turntable and carried thereby. This boom is provided with side guys back to the sides of the turntable. The boom is journaled on the turntable and is further supported by guys extending to the heads of the pivoted masts.

The masts are adapted to be held up or tilted backward or forward by adjustable back stays operated by the engine on the turntable. The boom may thus be tilted up or down or held in a horizontal position. By swinging the turntable by means of the engine thereon the boom may be moved to one side or the other and caused to follow a curve or to shift a section of the track laterally.

A sliding carriage mounted on the boom is drawn back and forth along the boom by an endless cable operated by engines on the turntable, the cable being adapted to be gripped by suitable clutches under the control of the operator seated in the chair suspended from the carriage.

On the carriage there will be seen four vertically slidable sashes, mounted two on each side of the center of the carriage. The two on one side move simultaneously with each other, while the two on the opposite side move simultaneously with each other. The opposite sets of sashes may be made to move simultaneously with each other or independently as desired.

It will be noted that one set may be drawn down while the other set is stationary or rising, or both sets may be raised or lowered or halted together. Supported by one set of sashes is a battery of shovel arms and shovels reaching to the opposite side of the track. The sashes are raised and lowered by engines on the upper platforms of the carriage through a system of gears and racks.

The lower ends of each battery of shovel arms are connected by links to horizontally sliding rack bars extending transversely of the machine beneath the boom and suspended in guides from said carriage. These rack bars are operated by the engines on the lower platforms of said carriage through a system of worms and pinions. Thus the lower end of the shovel arms may be moved outwardly away from the boom or *vice versa* by the rack bars and links at the same time that the sashes are being raised or lowered, or while the sashes are stationary.

It is clear that the shovels at the lower end of the shovel arms are independently tiltable to any desired angle forwardly or rearwardly, so that they may be tilted to proper angle to enter the earth to lift it or to scrape it or to tamp it, or to avoid bowlders or stumps. The upper ends of the outer shovel arms of each battery are pivoted to slide, which are movable transversely on the sashes of the carriage. The latter slides have racks connected by a system of worms, and gears, and telescopic shafts with the rack bars which move the lower ends of the shovel arms.

It is stated that these connections are so arranged that after the shovel arms have been drawn in at their lower ends there is automatic communication with the slides on the sashes which move inwardly at equal speed. The shovels thus move under the track in a horizontal plane and not on a radius and it is claimed danger of the shovels rising too far while under the track is thus obviated.

In each battery the intermediate shovel arms are swung from a connecting rod extending between the outer shovel arms. They are latched at their lower ends to lower connecting rods extending between the outer shovel arms. These intermediate shovel arms may be unlatched at any time from the lower connecting rods so that they will swing idly and drag the shovels over obstructions.

The gripping devices are suspended from the boom and are raised by cables running back to drums on the turntable. When in operation the car is run out by its own power to a point where the boom overhangs a depressed portion of the track. The gripping devices are then attached to the track and operated to raise a section of the same as noted in Fig. 3. If the track is out of line the turntable is used to swing the boom and suspended track to one side or the other. The shovels are then pushed out as indicated in Fig. 4, and the sashes lowered until the shovels engage earth at the side of the track. As noted in Fig. 2, the shovels are then drawn in and sashes raised until the new earth is brought into position beneath the ties.

The empty shovels are operated back and forth as indicated in Figs. 1 and 2, to tamp the earth, and the carriage is moved forward, as shown in Figs. 3 and 4,

Fig. 3.—TRACK GRADING MACHINE MOVING ANOTHER SECTION OF TRACK INTO NEW POSITION.

to ballast another battery length of track. When the carriage has reached the end of the boom, the section of track is dropped and the car run forward till the boom overhangs another or more depressed section when the operation is repeated.

It is stated that the machine is worked two or more times over the same depressed portion until the track is brought up to grade. In the finishing operation the shovels are tilted to get under the ties and ram the earth with their upper ends.

The machine is self-propelling at a speed up to 12 to 15 miles per hour, and it is stated that the track grapples can be detached from the rails and the machine positioned one length in advance and made ready to lift another section of track in thirty seconds, or while the carriage is moving back to the heel of the boom.

It is claimed that the operator while in his seat may operate the valve stems of two engines on the carriage with his feet and the valve stems of the other two with his hands. The overhead clutch cord provided for clutching the endless cable is controlled by hand, while the foot-operated valve stems are connected instead of hand levers so that the operation with the feet may be discontinued if desired. These valve stems are arranged to stop on the center and move to advance or reverse position as desired, while

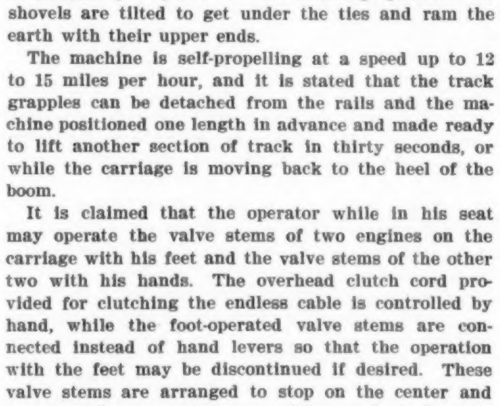


Fig. 4.—TRACK GRADING MACHINE WITH SHOVEL ARMS IN POSITION FOR MOVING GRADING MATERIAL FOR NEW SECTION OF TRACK.

if released they are automatically returned to center or stop position.

The operator when ready to put the brim on the grade raises the shovels to the level of the ties and moves them out and in horizontally. When working the track-grading machine on a prairie, it will lay track on unbroken ground, the machine reaching out for what dirt is accessible. The gravel train then dumps windrows by the side of the track to be drawn under the ties later by the machine. It is held that this machine, on account of its simplicity, economy of service, and great capacity, will largely reduce the losses by labor strikes and scarcity of competent labor.

OVER SWITZERLAND IN A BALLOON.

HOW IT FEELS TO LOOK DOWN ON THE ALPS.

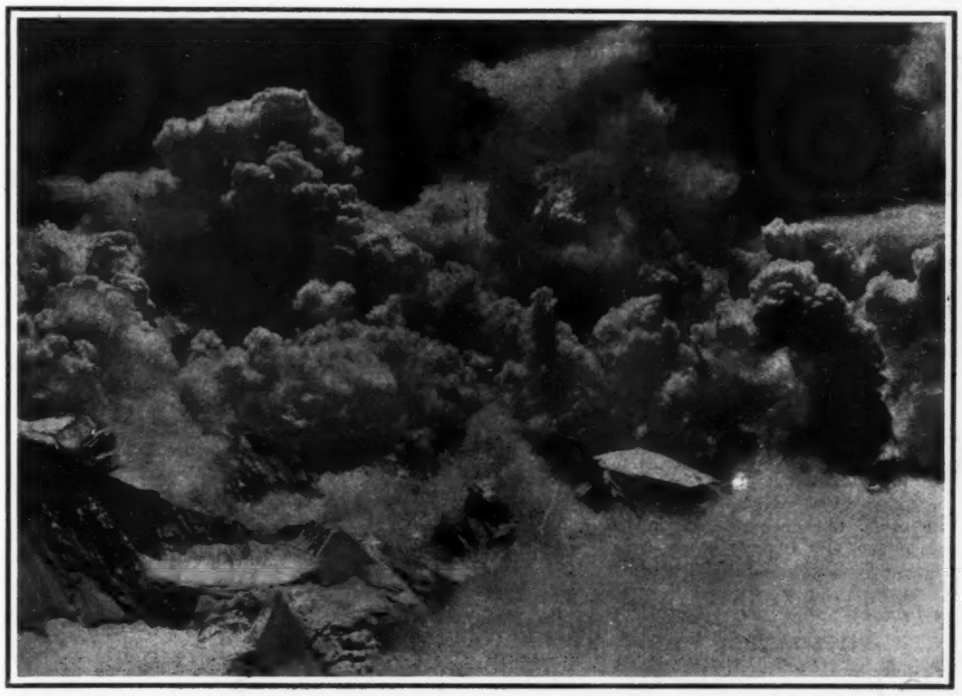
BY VICTOR DE BEAUCLAIR.

THERE was a time—not so many years ago—when high mountains were not known in all their beauty and when, strange though it now seems, they inspired only terror and affright. Little by little, men have discovered them and learned to love them, but even to-day few can experience without a shudder the profound impression created by great altitudes.

The best method of acquiring a thorough knowledge of the beauties of mountains is open to discussion, but if the object sought is the enjoyment of magnificent views—and this is the case with the great majority of tourists—the balloon certainly offers the most perfect means of exploration, because it enables its occupants to embrace in a single view a beautiful and extensive panorama which can be seen only in detail, and very imperfectly, by a traveler who is fettered to the ground.

No words can give an adequate idea of the diversity of the views which are obtained in ascending and descending, and in drifting over deep chasms and lofty peaks, amid scenes now of gentle picturesque loveliness, now of awe-inspiring wildness and grandeur. In addition, ballooning in the Alps is attended by difficulties of so intense interest that it may properly be included among the most fascinating of sports.

France is the fatherland of aeronautics, and it is fitting that a Frenchman should have been the first to cross the Alps in a balloon. This memorable pioneer flight is attributed to Arban, a French professional aeronaut, who was born at Lyons in 1820. When a very young man Arban made an ascent from Marseilles and, having been carried over the Alpes Maritimes by a violent storm, landed on the following morning near Turin. This exploit was due to a fortunate accident. No deliberately and rationally-planned crossing of the Alps in a balloon was accomplished until recent years. The creation of this new branch of aeronautic sport is due to the Swiss, Spelterini, who made the first voyage of this kind in October, 1898, ascending from Sion, in the canton of Valais. To give an idea of the difficulty of such an undertaking at that time, it is sufficient to note that more than 20 tons of white pyrites and 30 tons of sulphuric acid were used in the production of hydrogen, and that the filling of the balloon occupied more than a week. During this period the wind, which at first had been favorable to a flight over the highest peaks of the Bernese Alps, changed completely, so that the crossing was actually made over the Diablerets, 10,660 feet high, at the eastern end of the chain. Numerous similar crossings, starting from points within the Alps, have since been effected; for example: by Spelterini from Zermatt, over the Haut Dome (14,775 feet) and the Fletschhorn, to Bignasco, and from Andermatt over the St. Gothard to Italy, by Broeckelmann from Innsbruck over the Tux and the Ziller Valley to Luttach, and from Innsbruck over the Brenner to Brixen, by Frischknecht from Davos over the Piz Kesch and between the Bermina and the Ortler to Bolladore in the valley of the Adda, by Erlsloch from St. Moritz, in the Engadine, to Italy and Hungary, and, finally, by the writer, from Coire over the eastern Rhetic Alps, and again in winter, from Davos over the same chain, the Lech Valley and the Wetterstein.



CLOUDS OVERHANGING THE SUMMIT OF THE JUNGFRAU.

Photographed from a balloon at an elevation of 19,500 feet.

The greater difficulties which attend attempts to cross the Alps in balloons from points outside their boundaries made such attempts less successful than those cited above. Spelterini, for example, could not even make an ascension at Engelberg, and was unable to cross directly over the Rigi and the Eiger glacier, but was forced to content himself with skirting the principal range of the Swiss Alps. In the same category of attempts must be classed Usuelli's flight from Milan *via* the Bernina and the Ortler.

With the exception of Arban's adventurous journey, the first successful Alpine balloon voyages which started from points outside the mountains were made in the Austrian Alps, and even there only the most easterly spurs were crossed. The first of these flights was made by the Archduke Leopold Salvator and Capt. Hinterstoisser who, in April, 1902, with a balloon containing nearly 46,000 cubic feet of illuminating gas, succeeded in crossing the Dachstein and the Low Tauern, and landed near Judenburg. Capt. von Abercron descended near the same place six years later, after crossing the mountains alone, with a balloon containing only 13,400 cubic feet of hydrogen. Another trans-Alpine balloon voyage from the periphery of the mountains, though it was unexpectedly accomplished in those conditions, was Prof. Emden's flight at high altitudes, for purposes of scientific research, from Munich over the Kitzbuehl and between the High and the Low Tauern to Rennweg in Carinthia.

In reality, the first completely successful flight over the higher Alps was not accomplished until November, 1906, when Usuelli and Crespi, ascending from Milan, crossed the summit of the king of the Alps, Mont Blanc (16,000 feet), at an altitude of 22,300 feet, and descended near Aix-les-Bains, and thus won the prize offered by the Queen Dowager Margherita of Italy for a complete balloon traverse of the high Alps.

But the greatest and most attractive problem of Alpine aeronautics still remained—the crossing of the two most majestic ranges, the Bernese and Valais Alps, some of whose gigantic peaks are more than 13,000 feet high. The failure of repeated attempts to cross these ranges is explained by the fact that their general direction, from northeast to southwest, coincides with that of the prevailing winds of this region. The task was finally accomplished on June 29th and 30th, 1908, by the balloon "Cognac," in which the writer crossed the magnificent Jungfrau range, the most beautiful part of the Alps, in twenty hours. The balloon ascended from the Eigergletscher station of the Jungfrau railway and descended at Stresa, on Lake Maggiore. During nearly the entire voyage storm clouds of wonderful beauty formed a fitting frame for the lofty mountain. The photographs taken by my companion Gebhard Guyer, two of which are here reproduced, give a far better idea of these superb views than can be conveyed in words.

Suitably equipped for an Alpine balloon voyage, Gebhard Guyer, his wife, Konrad Falke, and the writer rose from the earth at a quarter past one in the afternoon, with 1,400 pounds of ballast. We crossed the southwest crest of the Moench (13,464 feet) and then soared at an elevation of nearly 16,000 feet over and among the giant peaks of the Bernese Oberland: the Jungfrau (13,670 feet), the Finsteraarhorn (13,960 feet), the Aletschhorn (13,700 feet), the Gruenhorn (13,380 feet), the Fischerhorn (13,280 feet), etc., to the "Place de la Concorde." The clouds, which at first were scattered and of unparalleled beauty, gradually assembled in groups and great masses. Flashes of

THE ALETSCHHORN VIEWED FROM A HEIGHT OF 15,000 FEET.

lightning appeared, peals of thunder followed, and we descended and dragged the guide rope for more than 7 miles, over the Aletsch glacier to its front in the deep and narrow ravine of the Massa. This was the most interesting part of the journey. We slowly rose again, crossed the Rhone valley near Brigue, and drifted toward Zermatt. There also, unfortunately, we found the mountain peaks surrounded by storm clouds, and we descended to seek a lower current which would carry us away from this dangerous region. We passed Simpeln on the drag rope, then rose and crossed the southern range of the Simplon and the Italian Alps in a stormy night illuminated only by almost incessant flashes of lightning. At daybreak we found ourselves over the plain of the Po, near Coggiola, and descended to the guide-rope level in order to obtain our bearings.

Our project of crossing the Alps in a balloon had been completely realized, but the wind carried us back to the mountain to say farewell. Now we attained our greatest elevation, 19,500 feet, and enjoyed an indescribably beautiful view of the whole of the Alps from the calm region above the clouds that encompassed them. At ten o'clock we landed within a few miles of Stresa on Lake Maggiore, overjoyed by the marvels which we had seen.

Three months later a similar crossing was effected by Spelterini, who ascended from Interlaken, and floated over the Bernese Oberland and the Visp and Lyskarum valleys. Still more recently, on January 1st, 1909, Usuelli ascended from Milan, crossed Mount Viso (12,600 feet) and landed at Fréjus. The most recent transalpine balloon voyage was made by Spelterini on August 8th, 1909. His balloon, the "Sirius," ascended from Chamonix, crossed the southern part of the Mont Blanc range and the whole length of the Valais Alps, and landed near Locarno, 87 miles from its starting point, after accomplishing one of the finest aerial journeys that can be imagined. Still more complete, though less picturesque, because the mountains were enveloped in clouds, was the flight made by the writer with the balloon "Cognac" on July 29th, 1909, from Zurich, over the whole extent of the Austrian Alps, to Boba in southern Hungary, a distance of more than 340 miles.

In addition to these great transalpine journeys, less extensive flights have been undertaken by members of the Swiss Aero Club. In these the Saenlis has been crossed and several landings have been made on the Vorarlberg and other spurs of the Alps. Similar flights have also been made in Dauphiny and in the Italian Alps, and I feel confident that, after the success of these preliminary experiments, ballooning in mountainous regions will soon become popular. I know no sport that furnishes more wholesome excitement.—Translated for the Scientific American Supplement from L'Illustration.

DARWIN AND BIOLOGY.*

THE WORLD OF LIFE AS VISUALIZED AND INTERPRETED BY DARWINISM.

BY ALFRED RUSSEL WALLACE, ESQ., O.M., D.C.L., LL.D., F.R.S.

The lecturer began by stating that, although the theory of Darwinism is one of the most simple of comprehension in the whole range of science, there is none that is so widely and persistently misunderstood. This is the more remarkable, on account of its being founded upon common and universally admitted facts of nature, more or less familiar to all who take any interest in living things; and this misunderstanding is not confined to the ignorant or unscientific, but prevails among the educated classes, and is even found among eminent students and professors of various departments of biology.

Darwinism is almost entirely based upon these external facts of nature, the close observation and description of which constituted the old-fashioned "naturalists," and it is the specialization in modern science that has led to the misunderstanding referred to. Those who have devoted years to the almost exclusive study of anatomy, physiology, or embryology, and that equally large class who make the lower forms of life (mostly aquatic) the subject of microscopical investigation, are naturally disposed to think that a theory which can dispense with all their work (though often strikingly supported by it) cannot be so important and far-reaching as it is found to be.

NUMBERS, VARIETY, AND INTERMINGLING OF LIFE-FORMS.

Coming to the first great group of facts upon which Darwinism rests, the lecturer calls attention to the great number of distinct species both of vegetable and animal life found even in our own very limited and rather impoverished islands, as compared with the more extensive areas. Great Britain possessed somewhat less than 2,000 species of flowering plants while many equal areas on the continent of Europe have twice the number. The whole of Europe contains 9,000 species, and the world 136,000 species already described; but the total number, if the whole earth were as well known as Europe, would be almost certainly more than double that number or about a quarter of a million species. The following table showing how much more crowded are the species in small than in large areas, was exhibited on the wall. It affords an excellent illustration of the fact of the great intermingling of species, so that large numbers are able to live in close contact with other, usually very distinct, species.

NUMBERS OF FLOWERING PLANTS.†

	Square Miles.	Species.
The County of Surrey..........	760	840
A portion containing..........	60	660
A portion containing..........	10	600
A portion containing..........	1	400

The above figures were given by the late Mr. H. C. Watson, one of our most eminent British botanists, and as he has lived most of his life in the country, they are probably the results of his personal observation, and are therefore quite trustworthy.

Continuing the above inquiry to still smaller areas, one perch, equaling 1/160 acre, or less than the 1/100,000 of a square mile, has been found to have about forty distinct species, while on a patch 4 feet by 3 feet in Kent (or about 1/25,000,000 of a square mile) Mr. Darwin found twenty species.

The same law of increase of numbers in proportion to areas applies to the animal world, if we count all the species that visit a garden or field during the year, though those that can continuously live there are not perhaps so numerous in very small areas.

THE INCREASE OF PLANTS AND ANIMALS.

The powers of increase of plants and animals were next discussed, and were shown to be enormously great. An oak tree may produce some millions of acorns in a good year, but only one of these becomes a tree in several hundred years, to replace the parent. Kerner states that a common weed, *Sisymbrium Sophia*, produces about three-quarters of a million of seeds; and if all of these grew and multiplied for three years, the plants produced would cover the whole land surface of the globe.

Equally striking is the possible increase in the animal world. Darwin calculated that the slowest breeding of all animals, the elephant, would in 750 years from a single pair produce nineteen millions. Rabbits, which have several litters a year, would produce a million from a single pair in four or five years, as they have probably done in Australia, where they have become a national calamity. As illustrative of this part of the subject, the lecturer referred at some length to the cases of the bison and the passenger pigeon in North America, and the lemmings of Scandinavia. In the insect tribes still more rapid powers of increase exist. The common flesh fly goes through its complete transformations from egg to perfect insect in two weeks; and Linnæus estimated that three of these flies could eat up a dead horse as quickly as a lion.

It is these enormous powers of rapid increase that have insured the continuance of the various types of existing life from the earliest geological ages in unbroken succession; while they have also been an important factor in the production of new forms which have successively occupied every vacant station with specially-adapted species.

INHERITANCE AND VARIATION.

The vitally important facts of inheritance with variation was next discussed, and their exact nature and universal application pointed out. The laws of the frequency and the amount of variations, and their occurrence in all the various parts and external organs of the higher animals, were illustrated by a series of diagrams. These showed the actual facts of variation in adult animals of the same sex obtained at the same time and place, which had been carefully measured in numbers varying from twenty to several thousand individuals.

The general result deduced from hundreds of such measurements and comparisons was, that the individuals of all species varied around a mean value—that the numbers became less and less as we receded from that mean, and that the limit of variation in each direction was soon reached. Thus, when the heights of 2,600 men, taken at random, were measured, those about 5 feet 8 inches in height were found to be far the most numerous. About half the total number had heights between 5 feet 6 inches and 5 feet 10 inches, while only ten reached 6 feet 6 inches, or were so little as 4 feet 10 inches, and at 6 feet 8 inches and 4 feet 8 inches there were only one of each.

The diagrams from the measurements of various species of birds and mammals were shown to agree exactly in general character; and the further fact was exhibited by all of them, that the parts and organs varied more or less independently, so that the wings, tails, toes, or bills of birds were often very long, while the body, or some other part, was very short, a point of extreme importance, as supplying ample materials for adaptation through natural selection.

THE LAW OF NATURAL SELECTION.

The next subject discussed was the nature and mode of action of natural selection. It was pointed out that since the glacial epoch no decided change of species had occurred. This showed us that the adaptation of every existing species to its environment was not only special but general. The seasons changed from year to year, but the extremes of change only occurred at long intervals, perhaps of many centuries, with lesser, but still very considerable, variations twice or thrice in a century. It was by the action of these seasons of extreme severity at long intervals, whether of arctic winters, or summer droughts, that the very existence of species was endangered; and it was at such times that the enormous population of most species, and their wide range over whole continents, always secured the preservation of considerable numbers of the best adapted in the most favored localities. Then the rapidity of multiplication came into play, so that in two or three years the population of each species became as great as ever; while, as all the least favorable variations had been destroyed, the species as a whole had become better adapted to its environment than before the almost catastrophic destruction of such a large proportion of them.

It is the fact of the adaptation of almost all existing species to a continually fluctuating environment—fluctuating between periodical extremes of great severity—that has produced an amount of adaptation that in ordinary seasons is superfluously complete. This is shown by the well-known fact that large numbers of adult animals that have not only reached maturity but have also produced offspring and successfully reared them, continue to live and breed for many years in succession, although varying considerably from the mean, while almost the whole of the inexperienced young fall victims to the various causes of destruction that surround them.

THE NATURE OF ADAPTATION.

The next subject discussed was the complex nature of adaptations in many cases, and probably in all; a subject of great extent and difficulty. The lecturer directed special attention to the relations between the superabundance of vegetation in spring and summer, the enormous, but to us mostly invisible, hosts of the insect tribes which devour this vegetation, and the great multitudes of our smaller birds whose young are fed almost exclusively on these insects. Without these hosts of insects the birds would soon become extinct; while without the birds the insects would increase so enormously as to destroy a considerable amount of vegetable life, which would, in its turn, lead to the destruction of much of the insect, and even of the highest animal groups, leaving the world greatly impoverished in its forms of life.

The vast numbers of insects required daily and hourly to feed each brood of young birds was next referred to, and the wonderful adaptation of each kind of parent bird which enables it to discover and to capture a sufficient quantity immediately around its nest, in competition with many others engaged in the same task in every copse and garden, was next pointed out. The facts were shown to involve specialties of structure, agility of motions, and acuteness of the senses,

* Abstracted by Popular Science Monthly from a lecture before the Royal Institution of Great Britain.

† Other tables illustrating similar facts in other parts of the world were prepared, but not exhibited, as being likely to distract attention from the lecture itself.

which could only have been attained by the preservation of each successive slight variation of a beneficial character throughout geological time; while the emotions of parental love must also have been continuously increased, this being the great motive power of the strenuous activity exhibited by these charming little creatures.

LORD SALISBURY ON NATURAL SELECTION.

As illustrating the strange and almost incredible misconceptions prevailing as to the mode of action of natural selection, the lecturer quoted the following passage from the late Lord Salisbury's presidential address to the British Association at Oxford in 1894. After describing how the diverse races of domestic animals have been produced by artificial selection, Lord Salisbury continued thus:

"But in natural selection who is to supply the breeder's place? Unless the crossing is properly arranged the new breed will never come into being. What is to secure that the two individuals of opposite sexes in the primeval forest, who have been both accidentally blessed with the same advantageous variation, shall meet, and transmit by inheritance that variation to their successors? Unless this step is made good the modification will never get a start; and yet there is nothing to insure that step but pure chance. The law of chance takes the place of the cattle breeder or the pigeon fancier. The biologists do well to ask for an immeasurable expanse of time, if the occasional meetings of advantageously varied couples, from age to age, are to provide the pedigree of modifications which unite us to our ancestors, the jelly-fish."

Here we have the extraordinary misconception presented to a scientific audience as actual fact, that advantageous variations occur singly, at long intervals, and remote from each other; each statement being, as is well known, the absolute reverse of what is really the case. It totally ignores the fact that every abundant species consists of tens or hundreds of millions of individuals, and that as regards any faculty or quality whatever, this vast host may be divided into two portions—the less and the more adapted—not very unequal in amount. It follows that at any given time, in any given country, the advantageous variations always present are not to be counted by ones and twos, as stated by Lord Salisbury, but by scores of millions; and not in individuals widely apart from each other, but constituting in every locality or country somewhere about one-half of the whole population of the species.

The facts of nature being what they are, it is impossible to imagine any slow change of environment to which the more populous species would not become automatically adjusted under the laws of multiplication, variation, and survival of the fittest. Almost every objection that has been made to Darwinism assumes conditions of nature very unlike those which actually exist, and which must, under the same general laws of life, always have existed.

PROTECTIVE COLOR AND MIMICRY.

The phenomena of protective coloration and mimicry were very briefly alluded to, both because they are comparatively well known and had formed the subject of previous lectures; while they are very easily explained on the general principles now set forth. The explanation is the more easy and complete, because of all the characters of living organisms, color is that which varies most, is most distinctive of the different species, and is almost universally utilized for concealment, for warning, or for recognition. And further, its useful results are clear and unmistakable, and have never been attempted to be accounted for in detail by any other theory than that of the continuous selection of beneficial variations.

THE DISPERSAL OF SEEDS.

The subject of the dispersal of seeds through the agency of the wind, or of carriage by birds or mammals in a variety of ways, and often by most curious and varied arrangements, of hooks, spines, or sticky exudations almost infinitely varied in the different species, was also briefly treated, since they are all readily explicable by the laws of variation and selection, while no other rational explanation of their formation has ever been given.

CONCLUSION.

In concluding, the lecturer called attention to a series of cases which had shown us the actual working of natural selection at the present time. He also explained that these cases were at present few in number, first, because they had not been searched for; but perhaps mainly, because they only occur on a large scale at rather long intervals, when some great and rather rapid modification of the environment is taking place.

In the following paragraph he endeavored to summarize the entire problem and its solution:

"It is only by continually keeping in our minds all the facts of nature which I have endeavored, however imperfectly, to set before you, that we can possibly realize and comprehend the great problems presented by the 'World of Life'—its persistence in ever-changing but unchecked development throughout the geological ages, the exact adaptations of every species to its actual environment, both inorganic and organic, and the exquisite forms of beauty and harmony in flower and fruit, in mammal and bird, in mollusk and in the infinitude of the insect tribes; all of which have been brought into existence through the unknown but supremely marvelous powers of life, in strict relation to that great law of usefulness, which constitutes the fundamental principle of Darwinism."

RETURN OF HALLEY'S COMET.

AN EPHEMERIS FOR THIS YEAR.

On September 11th, 1909, Prof. Max Wolf, at Heidelberg, detected the image of Halley's comet on a photograph taken (presumably) with the Bruce telescope of the Königstuhl Observatory. It is extremely satisfactory to learn that the comet was found in very close proximity to the place predicted in the ephemeris computed by Messrs. Cowell and Crommelin. Photographs of the region obtained at Greenwich with the 30-inch reflector on September 9th also show the comet, but this was not recognized until the definite news came from Prof. Max Wolf. The closeness of the predicted positions will be seen from the following comparison:

	R. A.	Decl.
Position at 14h. 7.3m. Konigstuhl mean time	6h. 18m. 12s.	+ 17° 11′
Computed from Cowell and Crommelin's Ephemeris	6h. 18m. 4s.	+ 17° 16′

Subsequently photographs were obtained at the Lick and Yerkes observatories, and from the positions thus available a corrected ephemeris has been prepared.—(A. C. D. Crommelin, Observatory, October, 1909, p. 400.)

EPHEMERIS FOR OBSERVATIONS OF HALLEY'S COMET AT 8:40 P. M. GREENWICH MEAN TIME.

	R A.	Decl.	Mag.
1909, November 1	5h. 51m. 40s.	+ 16° 52′N	14.0
November 6	5 42 33	16 49	13.7
November 11	5 31 32	16 44	...
November 16	5 18 33	16 38	13.2
November 21	5 3 23	16 26	...
November 26	4 46 13	16 13	12.7
December 1	4 26 56	15 52	...
December 6	4 6 13	15 23	12.3
December 11	3 44 24	14 45	...
December 16	3 22 19	14 4	11.9
December 21	3 0 34	13 18	...
December 26	2 40 11	12 28	11.7

REVISED ELEMENTS.

Perihelion passage .... 1910, April 20th
Longitude of ascending node. 57° 16′ 12″
Node to perihelion.......... 111 42 16
Inclination of orbit........ 162 12 42
Semi-major axis of ellipse.. 17.94527
Eccentricity 0.967281

Dr. Downing thinks that from the observed photographic magnitude of the comet it should be visible to the eye with a telescope of about 12 inches aperture. On October 15th its magnitude was about 14.5, its distance being about 230 million miles. At the beginning of November it will be almost in the continuation of the line through ξ and ν Orionis, and nearly north of the red star Betelgeuse (α Orionis). Of course, it is possible that the comet may be specially rich in blue and violet radiation, as was the case with Comet Morehouse, and not be easily visible to the eye at present even with considerable optical aid. Situated near the northern border of the constellation of Orion it will be excellently adapted for observation after midnight throughout the next two months. It is calculated to be approaching the earth at the rate of about 1,500,000 miles per day.

Mr. Crommelin finds that there is great probability that the comet will transit the sun's disk some time next spring (about May 18th), and this suggests the interesting problem of attempting to photograph it by means of the spectroheliograph. If we are fortunate enough to become familiar with its spectrum in the near future, it will be possible to suggest what wavelength should be transmitted by the secondary slit of the instrument, and it is hoped that by the relative intensification of the special cometary radiation some indication of the nucleus and coma may be photographed. A detailed ephemeris for this will be furnished later.—Knowledge and Scientific News.

THE HAND AND ITS CUNNING.

Perhaps some people would be embarrassed for a moment if they were asked to describe the ideals which led to the creation of a Philomathic Society, or at least until they had had time to reflect that the word "mathematics" signified to the Greek in the first instance the whole field of learning. It is then only fitting that a society banded together by its common love of learning should now and then bid as the chief guest to its yearly banquet a distinguished exponent of medical knowledge. When the Liverpool Philomathic Society invited Sir Frederick Treves recently to the chair of honor it paid its homage to art no less than to science, and their guest, whose art has been shown with pen as well as scalpel, devoted his address to the praise of handicraft and in some measure to a lament for its decline among men. He reminded his audience that the surgeon is above all the man who uses his hands, and after asking whether mankind is, as a whole, losing that wonderful function, he felt constrained to answer yes. In spinning, weaving, sewing, carving, writing, countless human hands have been for ages employed, with the result that works of surpassing excellence and variety have been produced. None will deny that the advance of handicraft since the days when it was confined to the shaping of flints and the preparation of hides for garments has been so amazing as almost to stagger contemplation. But, says Sir Frederick Treves, with the perfection of mechanical skill the zenith of human handicraft has been passed. We are losing as a race the capacity for the finer movements of the fingers now that the loom, the sewing machine, and the typewriter have reduced the products of a million hands into a soulless level of uniformity. Many instances present themselves to support the thesis. Metal, instead of being wrought, is cast in molds; furniture is decorated by stamping machines; the camera and the electric bath have well-night killed the engraver's art; and if there still be such craftsmen among us as were at once the wonder and the glory of the middle ages, their hands find no similar expression for their capacities, for there is only here and there a purchaser for slow-wrought, and therefore costly, wares. Sir Frederick Treves sighed for the day of hand-made lace and hand-made boots, and every book lover will join with him in his eulogy of the crafts of paper making and bookbinding when carried on by hand. From his own profession he drew a striking instance of how the progress of invention may trend toward the decline of handicraft. He could imagine few phases of activity more difficult or more subtle than that displayed by the facile operator in the pre-anæsthetic days. Now there is no call to be brilliant, for the surgeon can proceed with easy deliberation, and "in place of the flashing of a blade is an action as studied as a movement on a chessboard." (We quote from the report of his speech in the Liverpool Courier.) He acknowledged that surgery has gained more than it has lost, but thought that nevertheless it no longer attains to its former perfection as a handicraft. We cannot wholly indorse Sir Frederick Treves's view here. The modern surgeon is called upon to perform manipulations in the depths of the abdomen, the pelvis, and even in the brain itself that never tried the hand and eye of the dexterous men whose exploits of amputation or lithotomy were timed by the second hand of the watch. And in any general indictment of machinery it must be remembered that the machine may be regarded as the extension of the human hand called into existence by the exercise of the highest faculties of the brain. But we agree with much of Sir Frederick Treves's lament. The hand-made thing is almost always an honest thing, being what it professes to be, and often possessing a character and beauty that no machine can ever imitate, because it depends upon a human individuality. On the other side, art will never perish from the world, even though it be less and less applied in common craftsmanship. When, for instance, China has "occidentalized" herself, her artists will doubtless desist from the carving of concentric hollow spheres in patterns of bewildering intricacy, and will turn to more fruitful occupations, but we cannot think that the cunning spirit made manifest in the ivory will fail to find new expression among the people who gave it birth. Rather, we believe that men of the crafts which have produced lovely things for many centuries will find the artistic energy that directed their fingers passing into new forms of usefulness and beauty.—Lancet.

ENGINEERING NOTES.

Except for a few short distances, totaling 127 miles, automatic block signals now extend from the Atlantic to the Pacific Ocean. According to the Railroad Age Gazette, of the distance unprotected by this system, 93.4 miles on the Southern Pacific in the Sierra Nevada Mountains uses the electric-train staff. The next longest gap, 20 miles in length, occurs where a change of line is about to be made. The remaining gaps are due to bridges and points where changes are in progress. The line thus operated by the block system extends from Jersey City on the Atlantic to Oakland on the Pacific, over a total distance of 3,245 miles, and it includes the Lehigh Valley Railway to Buffalo, the Lake Shore & Michigan Southern to Chicago, the Chicago & North-Western to Council Bluffs, the Union Pacific Railway to Ogden, and the Southern Pacific Railway to Oakland.

A writer in the Foundry points out that blowholes, fissures, and shrinkages in castings are frequently due to the manner in which the metal is melted in the crucible, rather than to bad sand, occluded air, and disturbances in pouring. The remedy he proposes is to sub-divide the charge into small units, so as to obtain a uniform metal of constant chemical composition. The charge of coke should merely cover the layers of pig iron, thus economizing fuel; and the charge is preferably made ready in a sheet-iron cylinder of the same diameter as the crucible, and provided with a removable cover at the bottom. This cylinder is lowered into the crucible, and enables the layers of coke and pig to be deposited in the exact situations they should occupy. The operation of charging is thereby simplified, and the exact weight of the charge can also be determined.

The possibility of gas engine silencers causing an explosion probably does not suggest itself to owners of gas engines, but the risk is one that cannot be ignored, and several failures of this kind have been experienced. Failure of this kind in connection with a 1,000-horse-power gas engine, recorded in the annual report of the Inspector of Factories, which led to fatal consequences, may be noted by those interested as a warning of the possibilities that exist in this direction. It should be remembered that unconsumed gas may at any time be discharged into the silencer through misfires, and that the hot gases of the next discharge may ignite them, causing an explosion which the outlet pipe cannot release in time to prevent a dangerous pressure. It would thus seem that safety lies only in making the silencer strong enough to stand the explosion, or in providing relief valves which will act quickly enough to prevent accident.

One of the latest pieces of apparatus for testing hysteresis and eddy-current losses is that by Epstein. Twenty-two pounds of test strips are required to make a test, and there has to be some careful machining to get the joints to butt accurately. This has led Messrs. Lloyd and Fisher to devise a similar apparatus to that of Epstein, but which only requires about 4½ pounds of testing iron, each strip measuring 10 inches by 2 inches. No machining is required, because instead of butting the ends together they are interleaved at the edges by special corner pieces, and in this way leakage is reduced. An interesting point brought out by tests with it is that hysteresis of both ordinary and silicon steels, magnetized normal to the direction of rolling, is 5 to 10 per cent higher than that of those magnetized parallel to rolling, but the eddy-current loss is the same in each case. Artificial "aging" by baking always increases the hysteresis loss, but may increase or may decrease the eddy-current loss. It may also alter the law of variation of hysteresis with flux density.

A paper by Mr. H. W. Whitten, read to the American Society of Heating and Ventilating Engineers, deals with the effect of wind on heating and ventilating installations. One noticeable effect during the prevalence of wind is the entrance of air through crevices. This is very familiar, but one more apt to be overlooked is the outflow of warmed air through apertures on the sheltered side of buildings owing to the partial vacuum there established. The author describes some typical tests made for the purpose of throwing light upon this effect. In the case of a school building cited it was found that the average loss of air velocity amounted to 477 feet per minute. Another school building heated and ventilated by the gravity indirect system showed an average loss of 20 per cent velocity from the delivery ducts and an addition of 60 per cent to the discharge velocity in rooms on the windward side, while rooms on the leeward side exhibited an increase of 30 per cent in the supply velocity and a decrease of 62 per cent in the discharge velocity. A still more striking demonstration was afforded by the case of a school building where, after stopping the fan and closing the supply ducts as well as all doors and windows, it was found that the volume of air passing through the discharge ducts was equal to the amount which the fan and supply ducts had been designed to deliver.

ELECTRICAL NOTES.

A new hydraulic plant is installed at present for securing an added amount of power for the Wegneralp electric railroad. The first plant which was built for this line is located on the White Lütschine, while the second plant uses the fall of the neighboring stream known as Black Lütschine. It is located near Burglauen in the valley of the stream, and uses a 166-meter head of water with a flow of 7 meters per second. The maximum water supply will give 10,000 horse-power, and one-half of this is now being used. In the station there are four main turbine sets of 1,250 horse-power each and two exciter sets. Pelton wheels running at 400 R.P.M. with governor and 2-meter fly-wheel are employed. The alternators are of the three-phase type and are operated at 7,500 volts.

A system of wireless signaling for airships has been invented by Dr. Friedrich Lux. The idea of the inventor, states the Electrical Engineer, is that all airships should be equipped with a receiving apparatus which will weigh only 6 pounds, and that wireless signaling stations should be equipped all over the country at about 50 kilometers apart. At intervals of five minutes these signal stations should send out wireless messages by which they could be identified and aviators informed of their whereabouts. A combination of a few letters would, it is suggested, be sufficient to distinguish one station from another; and by the increasing or decreasing strength of the electric impulse the aviator could tell whether he was approaching or receding from a particular station.

Hitherto the proposals to electrify main lines in Canada have been limited chiefly to the western sections of the Dominion where large water-powers are abundant. Mr. C. A. Steeves, Consul at Moncton, now reports that the electrification of the Grand Trunk Pacific, or National Trans-Continental Railway, from the St. Lawrence River to Muncton, is under the serious consideration of the railway company, the Dominion Government, and the New Brunswick Cabinet. Electrical engineers who have given the subject consideration declare the conditions to be entirely favorable. The distance between the St. Lawrence and Moncton is about 460 miles, and for a considerable part of the distance the line passes through dense forests of spruce and fir in Lower Quebec and Northern New Brunswick, as well as through the rich farming country along the Upper St. John Valley. What has given impulse to the new plan is that at Grand Falls on the St. John River, 170 miles from the St. Lawrence and 160 miles from Moncton, is found water-power estimated to be sufficient to develop energy enough for the working of the whole road.

The turbo-generator, if it is to oust the engine type of machine, states Mr. Mills Walker, must have carbon brushes, or, at least, brushes which hardly wear at all and do not wear the commutator. It is true that metal-brush machines are made to operate fairly satisfactorily in the hands of careful attendants. But if the brushes are left without attention they soon wear so as to cover the wrong arc, and begin sparking and burning. Even in the best hands the wear of the brushes is considerable, the whole set having to be renewed every two or three months. The wear of the brushes fills the air with fine copper dust, which settles on insulating surfaces, and is often the cause of breakdowns. Carbon brushes can be made which will run for years without removal, always occupying the same arc and giving to the commutator a bright gloss, so that after years of running only the slightest wear can be detected. Electrical engineers owe a great deal to the makers of carbon brushes for the way in which they have solved the problem of brush manufacture and given us such excellent brushes. It is a pity to throw away all the advantages of carbon brushes and go back to metal brushes.

In the early days, when 110 volts only had to be dealt with, flexibles insulated with lapped rubber tape were successfully employed. When, however, 220 volts came into use, this class of insulation was found to be insufficient, the faults mostly occurring in the switch wires. This was largely due to considerations of price, which led to the employment of insulation material containing sometimes from 50 per cent to 70 per cent of rubber substitutes, and also to faulty manufacture in giving too small an overlap to the rubber tape spirals, so that in some cases the wire was uncovered. Under the new German regulations taped rubber flexibles may only be used in dry living rooms for pressures up to 125 volts. They may not be used under fabrics or for portable fittings, and may not be installed in cellars, under floors, in bedrooms, or halls. Vulcanized rubber in the form of a continuous sheath may, however, be used up to 1,000 volts for fixed apparatus and up to 500 volts for portable purposes. The trouble at 220 volts with taped rubber flexibles is due, not so much to a direct short-circuit, which would blow the fuses, as to the persistent arcs of low current value, which are carried by the fuses.

TRADE NOTES AND FORMULÆ.

To prepare cherry tubes (Weichsel pipe stems) so that they have a pleasant and powerful aroma, Gawalowski recommends a strong solution of 10 parts of tonka beans, 0.25 part vanilla pods, 0.10 part of Bismark brown in 1,000 parts and 1 part of glycerine. Jolles impregnates the wood with coumarin solution.

Incense for Church Use.—I. 125 parts (grammes) benzoin, 125 parts (grammes) storax, 175 parts (grammes) myrrh, 100 parts (grammes) cascarilla, 30 parts (grammes) oil of cinnamon, 20 parts oil of bergamot, 20 drops oil of lavender, 20 drops oil of cloves. II. Equal parts of storax, benzoin, galbanum and olibanum.

To Remove Copper from Wine.—The treatment of grapes with Bordeaux mixture may result in the presence of copper in the wine. Crouzel precipitates it by the introduction of bright iron in the must. At the same time, the solution of the iron will result in the separation of a certain proportion of tannin, which must be replaced.

Wadding Paper (a pipe-covering or heat-insulating substance).—This consists of two layers of tough, strong paper, between which a layer of cotton, wool, hair, etc., is disposed, with the aid of an adhesive, so that the two paper sheets, with the intervening substance, forms a single layer. This is wound spirally in one or two thicknesses about the pipe to be protected and secured with twine.

Destruction of Roaches, Bugs, etc.—I. Angelica root, ground fine, 1,000 parts, eucalyptus oil 20 parts, intimately mixed in a mortar. The powder is to be scattered at night in all places frequented by the vermin mostly on the floors of kitchens and pantries. II. Roach and bug powder: Mix intimately (1) 2 parts borax, 1 part wheat flour; (2) 1 part borax, 1 part insect powder, ½ part wheat flour; (3) 2 parts borax, 1 part each insect powder and wheat flour. III. Bug destroyer consists of 2 parts borax and 1 part salicylic acid.

Method of Cleansing Soiled Drawings.—The choice of the method to be adopted depends on the nature of the dirt spots. Ink spots may be removed with the aid of a not too concentrated warm solution of oxalic acid. For many spots (coffee, etc.), the following process is suited: Apply to the spot pulverized magnesia, stone-alum (fibrous gypsum), or similar substance, lay some white filter paper on it and saturate the latter with a solution of peroxide of hydrogen. After a few hours, the medium is removed by means of a paint brush and, as a rule, the first time, if not, by a repetition of the operation, the drawing will have become cleansed without erasing.

Sulphurless Igniting Mass.—According to a German process, 25 parts of adhesive (gum, dextrine, etc.), 60 parts chlorate of potash, 5 parts of a resinate or oleic metallic compound (such as palmatinate of manganese), 8 parts of a neutral fatty substance (which, according to the desired color of the tips or scratch heads may be colored with zinc-white, oxide of iron, ultramarine, etc.), and 2 parts chromate of potash, with the requisite quantity of water, and work this, in the known manner, into a dippable igniting mass. The latter, in a finely ground condition, is affixed to the paraffine sticks by dipping, and this mass may be made to ignite and burn without any offensive effect on organs of smell and of respiration.

Ink Eradicators.—A. (1) 1 part citric acid, 2 parts saturated borax solution, 10 parts water. (2) 3 parts of chloride of calcium, 2 parts saturated borax solution, 16 parts of water. With a fine brush the writing to be removed is painted over with solution (1), the superfluous fluid removed by means of filter paper, and solution (2) then applied, in the same manner, with another brush. B. (1) 1 part each chloride of potassium and hypochloride of potassium, 3 parts water. (2) 1 part each hydrochloric acid and chloride of sodium and 3 parts of water. Proceed in the same manner, as described under A; only, solution (1) must be allowed to dry on the writing before applying (2). Both methods may also be employed for removing ink spots from fabrics.

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